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ONTARIO GEOLOGICAL SURVEY

Open File Report 6090

Geology of Mafic Intrusions of Flett and Angus Townships, Grenville Province

by

R.M. Easton

2002

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GEOLOGICAL MAP

P.3452 Precambrian geology of mafic intrusive rocks of Flett and Angus townships............ back pocket

Abstract

The Fanny Lake and Fall Lake intrusions are located in Flett and Angus townships and are roughly 32 km southeast of the community of Temagami, Ontario. This study focussed on the tectonic affinity and mineral potential of these intrusions, which previously had not been studied in detail.

The study area comprises approximately 25 km^2, and lies within the Grenville Province, near the boundary between the Grenville Front tectonic zone and the Tomiko domain of the Central Gneiss Belt. The intrusions are located within the Mesoproterozoic Tomiko domain. Country rocks to the mafic intrusions consist mainly of gneissic granites of Proterozoic age, although mafic gneiss and gneissic quartz arenite and metaconglomerate are locally present.

Geochemical and geochronological data collected during this study indicate that the mafic intrusions are similar in age and overall chemical composition, and were emplaced at approximately 1235 million years ago. The mafic intrusions are similar in age and composition to the Sudbury diabase dike swarm. Felsic magmatism of similar age has previously been documented within the Tomiko domain.

The Fall Lake intrusion consists of metagabbros (amphibolites) that locally preserve igneous textures as well as leucotroctolites that show only minor metamorphic recrystallization. A stratigraphic sequence was not observed in the Fall Lake intrusion. Samples collected from the Fall Lake intrusion contain higher incompatible element contents than do samples from the Fanny Lake intrusion. Possible metasomatic titaniferous magnetite mineralization is found along the northeastern contact of the Fall Lake intrusion. Sulphide-bearing zones or above background levels of copper, nickel or platinum group elements (PGE) were not detected in the Fall Lake intrusion.

The Fanny Lake intrusion consists of olivinite and melatroctolite, troctolite and leucotroctolite and exhibits compositional layering at outcrop and intrusion-scales. Igneous textures are well preserved throughout most of the intrusion, with upper amphibolite-facies metamorphic recrystallization being most extensively developed along the western and southwestern margin of the intrusion. Even the best preserved samples of the Fanny Lake intrusion typically exhibit metamorphic corona textures developed around olivine grains. This texture is more widely developed in the Fanny Lake than the Fall Lake intrusion.

The Fanny Lake intrusion consists of a main body, characterized by near vertical, north-striking, west-facing compositional layering; and a northwest body, containing folded compositional layering. The 2 parts of the Fanny Lake intrusion are separated by a major shear zone, along which rocks of the Fanny Lake intrusion have been transformed into mafic gneiss. The most chemically fractionated rocks of the intrusion occur along the western margin of the Fanny Lake intrusion, and resemble rocks from the Fall Lake intrusion in overall chemical composition. Magnetite mineralization in the Fanny Lake intrusion is associated with alteration veins developed within olivinite and melatroctolite layers. Sulphide-bearing zones or above background levels of copper, nickel or platinum group elements were not detected in the Fanny Lake intrusion.

The intrusions are interpreted to have formed in an extensional rift that developed inboard of a continental arc that was present along the southern margin of the North American continent between 1450 and 1300 Ma. This setting resembles that of the Cenozoic Columbia River Basalt Group in western North America. The extension rift setting lead to the formation and emplacement of both mafic and felsic magmas into the northern Ontario Grenville Province between 1270 and 1225 Ma. Mafic intrusions of this age include the Sudbury dike swarm, the Fanny Lake and Fall Lake intrusions and the Mercer anorthosite. Coeval felsic intrusions include the Mulock, West Bay and Powassan batholiths.

The mafic intrusions, particularly the Fall Lake intrusion, are favourable targets for titanium–iron–vanadium mineralization. The Fanny Lake intrusion may have potential as a source of building stone. Key features of current models for the formation of magmatic copper–nickel–PGE deposits appear to be absent in the intrusions, namely 1) the absence of sulphur-undersaturated magmas; 2) the absence of high volumes of high temperature, high magnesium magmas, which are typically associated with mantle plumes; and 3) the absence of sulphide-bearing country rocks that could drive a sulphur-undersaturated magma to sulphur saturation.

Geology of Mafic Intrusive Rocks of Flett and Angus Townships, Grenville Province

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Ontario Geological Survey
Open File Report 6090
2002

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Introduction

Mafic intrusive rocks were first reported in Flett Township (Figures 1 and 2) by Barlow (1899), but little was known about the age or tectonic affinity of these mafic rocks. The latter questions are particularly important when it comes to evaluating the platinum group element mineral potential of these mafic rocks; for example, are these rocks correlative with the East Bull Lake intrusive suite, emplaced at 2475 Ma, which has high platinum group element (PGE) potential; or are they related to another, less prospective intrusive suite? This project was initiated in 2001 to determine the age, tectonic affinity and mineral potential of these mafic rocks.

The mafic rocks comprise 2 separate intrusions, one located in Flett Township, the other located in Flett and Angus townships, north of Fanny and Fall lakes, respectively (*see* Figures 1 and 2). The intrusions occur within the Grenville Front tectonic zone, roughly 32 km southeast of Temagami, and 10 to 12 km southeast of the Grenville Front, near the northern boundary of Tomiko domain (*see* Figures 1 and 2). Herein, the eastern body will be informally referred to as the Fall Lake intrusion, and the western body as the Fanny Lake intrusion (*see* Figure 2).

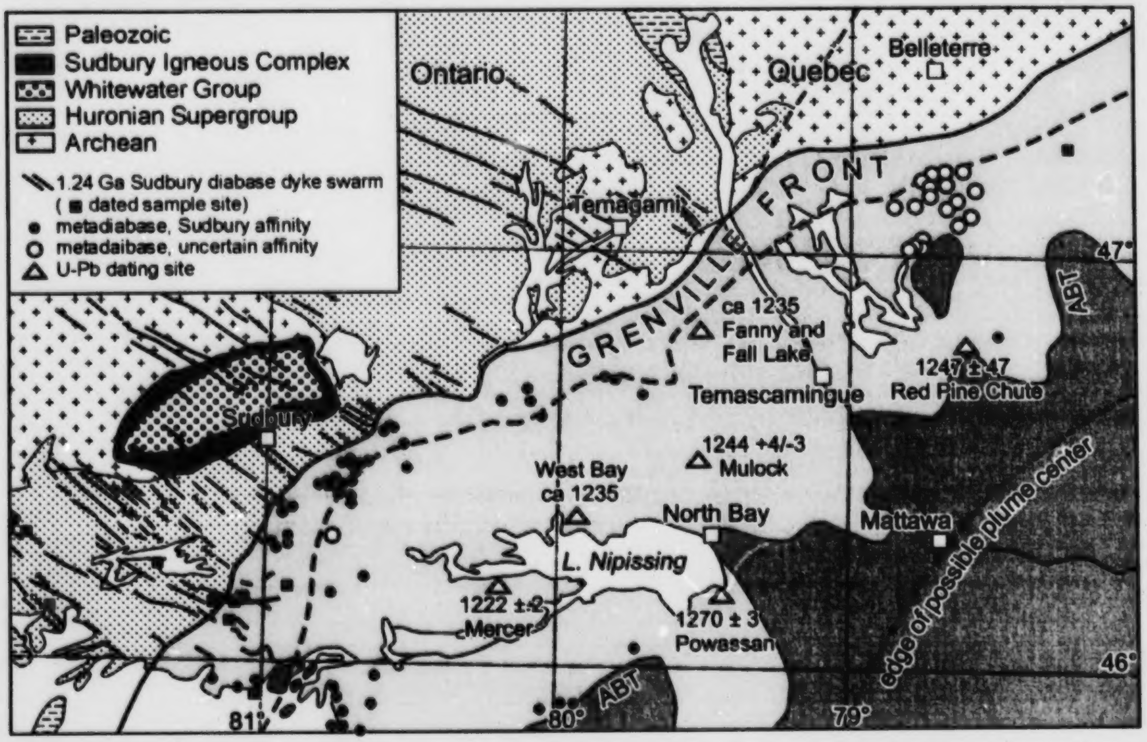
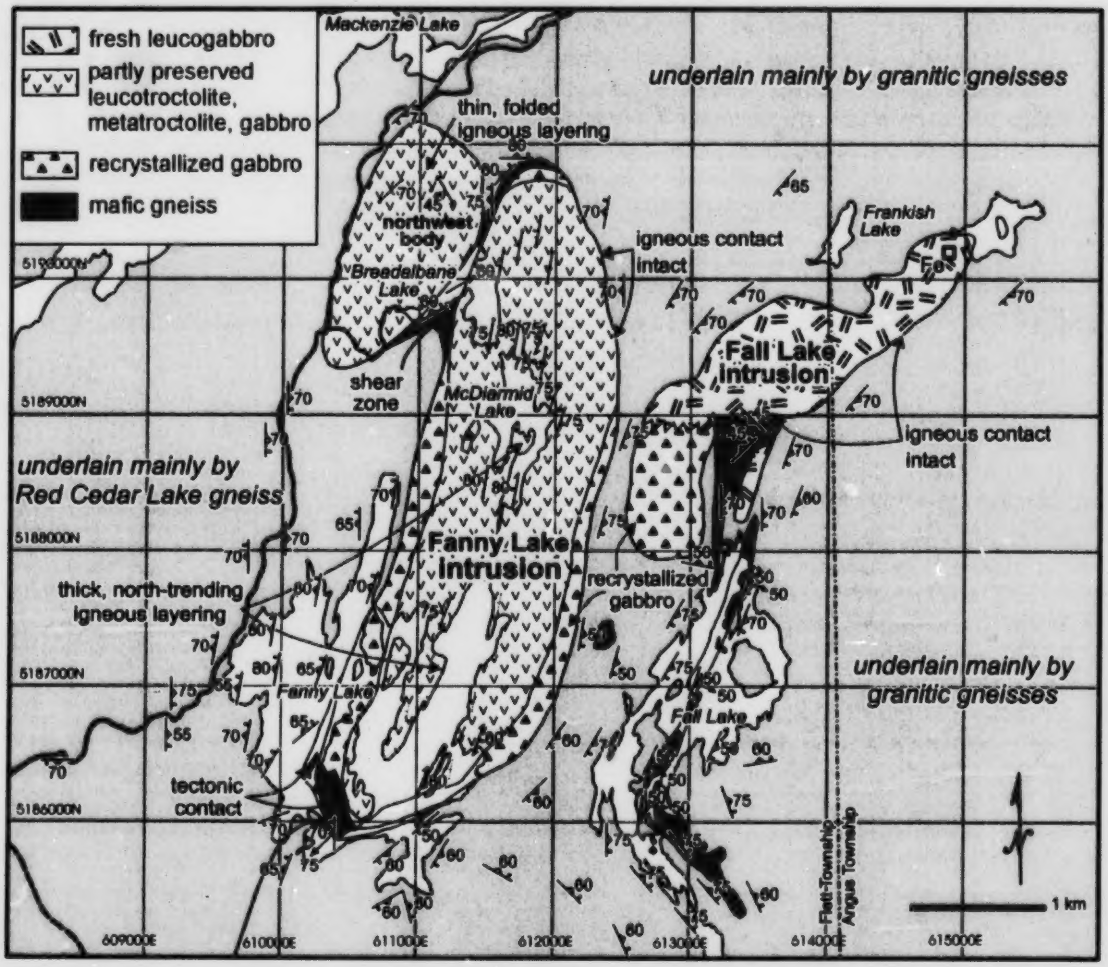

Paleozoic
Sudbury Igneous Complex
Whitewater Group
Huronian Supergroup
Archean
1.24 Ga Sudbury diabase dyke swarm
(■ dated sample site)
● metadiabase, Sudbury affinity
○ metadaibase, uncertain affinity
△ U-Pb dating site
Ontario
Quebec
Belleterre
Temagami
GRENVILLE FRONT
47°
ca 1235
Fanny and
Fall Lake
Temascamingue
1247 ± 47
Red Pine Chute
ABT
Sudbury
1244 +4/-3
Mulock
West Bay
ca 1235
North Bay
Mattawa
edge of possible plume center
L. Nipissing
1222 ± 2
Mercer
1270 ± 3
Powassan
46°
ABT
81°
80°
79°

Figure 1. Location map showing the location of the Fanny Lake and Fall Lake mafic intrusions in Flett Township; the distribution of the Sudbury diabase dike swarm dated at about 1240 Ma; the location of known intrusive rocks emplaced between 1270 to 1230 Ma in the northwestern Grenville Province; and the location of the possible plume centre that may have been responsible for magmatism in the region at about 1270 to 1230 Ma . Figure *modified from* Ketchum and Davidson (2000).

ACCESS

Access to the mafic intrusions is provided by float-equipped aircraft, which can land on Fall, Fanny or McDiarmid lakes. Access is also provided by the Ontario Northland Railway, which transects the extreme southwestern corner of the map area. A dirt road extends from the Kearney railway stop to the western edge of both Fanny and Breadalbane lakes. Fanny and McDiarmid lakes both provide excellent shoreline exposures of the Fanny Lake intrusion. Although Fall Lake provides access to the Fall Lake intrusion, it does not provide shoreline exposures of the intrusion.



fresh leucogabbro
partly preserved leucotroctolite, metatroctolite, gabbro
recrystallized gabbro
mafic gneiss
Mackenzie Lake
underlain mainly by granitic gneisses
thin, folded igneous layering
northwest body
Breadalbane Lake
igneous contact intact
Frankish Lake
Fe
Fall Lake intrusion
shear zone
McDiarmid Lake
igneous contact intact
underlain mainly by Red Cedar Lake gneiss
Fanny Lake intrusion
recrystallized gabbro
thick, north-trending igneous layering
Fanny Lake
Fall Lake
underlain mainly by granitic gneisses
tectonic contact
Flett Township
Angus Township
1 km
5190000N
5189000N
5188000N
5187000N
5186000N
609000E
610000E
611000E
612000E
613000E
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615000E

Figure 2. Sketch map showing key features of the Fanny Lake and Fall Lake intrusions.

PHYSIOGRAPHY

Relief in the map area is less than 100 m, ranging from approximately 304 m and 300 m above sea level at Fanny and Fall Lakes, respectively, to approximately 370 m northwest of Breadalbane Lake. The northwest body of the Fanny Lake intrusion is topographically higher than the main lobe, by approximately 30 m and, in general, all rocks of the Fanny Lake intrusion are topographically higher than the surrounding country rocks. The Fanny Lake intrusion is best exposed along the shores of Fanny and McDiarmid lakes and in the northern half of the northwest body. The Fall Lake intrusion is also topographically higher than the country rocks, and supports a distinctive, fern–alder–birch cover, particularly over areas underlain by leucotroctolite of map unit 13 (Map P.3452, back pocket).

Distribution of outcrop is varied. Exposure is poor (<20%) south and east of Fall Lake, and south and west of Fanny Lake; these areas are generally underlain by granitoid rocks of map unit 6 (Map P.3452, back pocket). Exposure is good (>40%) over parts of the Fanny Lake and Fall Lake intrusions, but is generally discontinuous across strike. Some units, such as the leucotroctolite unit within the Fanny Lake intrusion (map unit 9), are well exposed along continuous north-trending ridges, but are separated from one another by low areas where exposure is poor or absent. Access is hampered by the presence of dense bush throughout the study area.

PREVIOUS WORK

Weakly metamorphosed to apparently unmetamorphosed mafic intrusive rocks were first reported in Flett Township by Barlow (1899). Subsequently, Hurst (1932) described the O'Connor magnetite occurrence and reported a single chemical analysis from the Fall Lake intrusion. Hurst's (1932) map shows the mafic intrusions as a single body, however, Lumbers (1971a) interpreted them as 2 separate bodies of apparently different relative age, an observation confirmed by this study. Lumbers (1971a, 1971b) mapped the intrusions as part of his regional mapping study of the Tomiko area, but did not describe them in detail. He assigned them a late-Grenvillian age and his maps suggested that the intrusions had relatively well-preserved cores with deformed and metamorphosed margins.

Exploration work, mainly for iron and titanium, was conducted on the intrusions in the 1930s, 1940s, 1950s and the early 1970s. Between 1970 and 1972, W. Nicol explored for uranium in gneisses on the southwest shore of Fanny Lake. Between 1974 and 1996, the area was in the Temagami Land Caution and unavailable for staking.

Candol Developments Limited optioned a block of claims in Flett Township in 1988, and undertook a bulk sampling program, including the O'Connor magnetite occurrence (Owsiacki, Cosec and Anderson 1989). Exploration was renewed between 1996 and 1998 by Lake Superior Resources, which conducted geological mapping and airborne magnetic and radiometric geophysical surveys over the Fanny Lake intrusion in a search for nickel–copper–PGE mineralization (Racicot and Keevil 1998; Terraquest 1999). Lake Superior Resources also removed a test block from the Fanny Lake intrusion for evaluating building stone potential. In February 2001, Randsburg International Gold Corporation conducted induced-polarization and ground magnetometer geophysical surveys over the southern and the northeastern parts of the Fanny Lake intrusion. Temex Resources holds several claims immediately north of the intrusions, and JML Resources Ltd., in conjunction with Falconbridge Ltd., hold several claims immediately south of intrusions, all of which are part of larger claim blocks on which these companies are conducting diamond exploration programs.

PRESENT GEOLOGICAL SURVEY

Field work for the present geological survey (Project Number 01-008) was conducted by the author over a 5 week period during July and August 2002. Two base camps were used: one located on Fall Lake and the other on the northeastern shore of Fanny Lake. Able assistance was provided by C. Wilson during the field investigations. E.I. Murphy assisted with the office and laboratory investigations, particularly with respect to petrographic and electron microprobe studies, which were initiated while field work was ongoing. Preliminary results of this survey were reported in Easton (2001).

Map P.3452 (back pocket) presents the results of the geological survey carried out during the course of this project. Geological mapping was conducted using vertical aerial photographs at a scale of 1:20 000, obtained from by the Air Photo Library, Public Information Centre, Ontario Ministry of Natural Resources. Acetate overlays were used to record data that were collected on traverses run by the pace and compass method. Geology was not tied to surveyed lines. Traverses were not spaced at regular intervals, but were designed to include as many of the major outcrop areas as possible, particularly in areas of complex geology and along contacts between major rock units.

Information from mapping was plotted on Ontario Basic Mapping (OBM) 1:20 000 base maps supplied by the Ontario Ministry of Natural Resources, which were digitally combined and simplified. Recent information with respect to roads, buildings, power lines, rock and shoreline features, were added to the resulting base map.

Reference to specific locations (e.g., photographs, samples) in the text are given in Universal Transverse Mercator (UTM) co-ordinates because of the ability to pinpoint locations more precisely than by using latitude and longitude. The map area is located in UTM Zone 17T and co-ordinates are given using the NAD83 datum. Flett and Angus townships were not subdivided into lots and concessions.

TERMINOLOGY

A number of terms used in this report are outlined below.

Precambrian Time Scale

The Precambrian time scale as subdivided by Easton (1999) is used. This is an updated version of the time scale used for Geology of Ontario (Ontario Geological Survey 1992). Precambrian time is divided into 2 eons: the Archean (older than 2500 Ma) and the Proterozoic (between 2500 and 543 Ma). The Proterozoic is divided into 3 eras: Paleoproterozoic (2500 to 1600 Ma), Mesoproterozoic (1600 to 900 Ma) and Neoproterozoic (900 to 543 Ma).

Rock Classification

Terminology for all plutonic rocks in the area follows that of Streckeisen (1976). For metamorphic rocks, mineral prefixes are listed in order of relative abundance, starting with least abundant first. Mineral abbreviations follow Kretz (1983). The following conventions are used regarding descriptive adjectives. A *gneissic granite* is a meta-igneous rock of granitic composition. A *granitic gneiss*, a *granite gneiss*, or a *gneiss of granitic composition* may be either a meta-igneous or a metasedimentary rock. Similarly, a *tonalitic gneiss* or a *tonalite gneiss* is a gneiss of tonalite modal composition, but may be of either meta-igneous or metasedimentary origin. A *gneissic meta-arkose* is a metasedimentary gneiss of overall granitic composition.

The term metamorphic grade is used in the case where bulk-rock composition or other factors prevent a more detailed assignment of metamorphic conditions. Where metamorphic conditions can be outlined more precisely, the metamorphic facies terminology of Turner (1981) is used.

A migmatite is a heterogeneous rock composed of 2 or more components, one generally quartzofeldspathic in composition (leusosome or neosome) and the other more mafic in composition (paleosome or mesosome). In the study area, such rocks are commonly layered and, in many instances, are formed by partial melting during high-grade regional metamorphism. Descriptive terminology for these rocks follows Menhert (1969). Other related terms are: metatextite—a rock resulting from moderate degrees of partial melting in which leucosome is subordinate to mesosome; and diatextite—a rock resulting from high degrees of partial melting and containing substantial amounts of leucosome.

Foliation, Schistosity, Gneissosity, Cleavage

Foliation is used to describe all types of megascopic structural surfaces of metamorphic origin (Turner and Weiss 1963). Several distinguishable types of foliation include compositional layering and preferred orientation of mineral grains. Gneissosity and schistosity are the most common varieties of foliation in the map area. Gneissosity denotes a layering of metamorphic origin, defined by the alternation of layers, streaks, or lenticles on contrasting mineralogy or texture. The steaks or lenticles may be discontinuous. Schistosity is a planar structure in a metamorphic rock due to abundant, preferentially oriented grains, especially micas. Cleavage denotes a parting in the rock resulting from the parallel growth of micaceous or elongated minerals in fine- to medium-grained rocks.

Layering Thickness Terms

Layering thickness terms used in this report are listed below. These terms apply to bedded, layered and gneissic rocks.

Very thinly layered	<3 cm
Thinly layered	3 to 10 cm
Medium layered	10 to 30 cm
Thickly layered	30 to 100 cm (1 m)
Very thickly layered	1 to 3 m
Extremely thickly layered	>3 m

Geochemical Methods and Terminology

Except where otherwise stated, all chemical analyses that appear in this report were done at the Geoscience Laboratories, Geoservices Centre, Sudbury, Ontario. All chondrite-normalized rare earth element diagrams shown in this report use the chondrite-normalizing values of Sun and McDonough (1989). All geochemical data collected during this study are listed in Appendix 1. Analytical methods are described in Vander Voet and Riddle (1993). Appendix 2 lists the results of the mineral chemistry of various species from samples collected during this study from both the Fall Lake and Fanny Lake intrusions. Mineral chemistry data were collected by E.I. Murphy using a JOEL scanning electron microprobe and a CAMECA electron microprobe, both housed at the Geoscience Laboratories, Geoservices Centre, Sudbury, Ontario. Amphibole names based on mineral chemistry data follow the recommendations of Leake et al. (1997). With respect to assay data, the term anomalous is used with reference to background levels determined empirically by this study.

Geological Setting

The geologic setting of the study area is illustrated in Figure 1. To the northwest are Archean and Paleoproterozoic rocks of the Superior and Southern provinces; to the southwest are Archean and Mesoproterozoic rocks of the Grenville Province. The boundary between the two is marked by a series of faults, known collectively as the Grenville Front (*see* Figure 1). The Grenville Province in the area consists of 2 main divisions (*see* Figure 1): 1) the Grenville Front tectonic zone, which is a region immediately south of the Grenville Front, up to 15 km in width and dominated by Archean rocks reworked during the Grenville Orogeny; and 2) the Tomiko domain (Easton 1992), which is a region extending from Highway 11, east to the Ottawa River and south toward North Bay, dominated by Archean and Mesoproterozoic rocks. The mafic intrusions in Flett and Angus townships occur within the Tomiko domain near the boundary with the Grenville Front tectonic zone (*see* Figure 1). The area shown in Map P.3452 (back pocket) encompasses rocks located within both the Tomiko domain and the Grenville Front tectonic zone. Table 1 summarizes the geologic history of the region and the U/Pb age constraints on this history.

SUPERIOR AND SOUTHERN PROVINCES

The Superior Province in the region consists of Neoarchean supracrustal and plutonic rocks of the Temagami greenstone belt (Jackson and Fyon 1991). Although only limited geochronology has been performed on the Temagami greenstone belt, both U/Pb zircon ages and Ar/Ar hornblende ages in the range of 2730 to 2736 Ma have been obtained (Bowins and Heaman 1991; Smith et al. 1994; *see also* Table 1). The southern part of the granite-greenstone belt consists of a large, northeast-trending granodiorite intrusion known as the Ingall Lake batholith (Lumbers 1971a, 1971b, 1978)[1], which is cut in half by the Grenville Front. North of the Grenville Front, the intrusion is massive to foliated, generally exhibiting greenschist-facies mineral assemblages. South of the Grenville Front, the intrusion is gneissic, and generally contains amphibolite-facies mineral assemblages (Lumbers 1978).

Southern Province rocks in the region consist of low-grade (greenschist to sub-greenschist facies) metasedimentary rocks of the Paleoproterozoic Huronian Supergroup and mafic intrusive rocks, dated at about 2220 Ma (*see* Table 1), of the Nipissing intrusive suite. Huronian Supergroup rocks in the region consist of both the Coleman (conglomerate–mudstone–wacke) and Firstbrook (mudstone) members of the Gowganada Formation and arkosic quartz arenites of the Lorrain Formation. Both formations belong to the Cobalt Group, the stratigraphically highest of the 4 groups constituting the Huronian Supergroup. The Cobalt Group rests unconformably on underlying Neoarchean supracrustal and plutonic rocks. Gabbroic intrusions of the Nipissing intrusive suite intruded rocks of both the Superior and Southern provinces, generally near the trace of the Archean–Proterozoic unconformity in the region.

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[1] Jackson and Fyon (1991) named this body the Iceland Lake pluton, apparently unaware that it had been previously referred to as the Ingall Lake batholith by Lumbers (1971a, 1971b, 1978). The older usage is retained herein, in part because Lumbers' terminology is more established in the literature on the area.

Table 1. Timing of major geological events and summary of age constraints on the main rock units present in the North Bay to Temagami area. All ages are U/Pb zircon ages. Intrusive rocks of similar age to the Fanny Lake and Fall Lake intrusions are highlighted.

Event	Age Constraint (in Ma)	Source and/or Comment
Age of youngest "Grenvillian" tectonic activity along the Grenville Front	988±5	Krogh (1994)
FannyLake and Fall Lake intrusions	***1238±2 and 1235±2, respectively***	***This study and Ketchum (2002)***
Sudbury dike swarm	***1238±4***	***Emplaced in or along NW-trending faults in the Southern Province, but apparently not deformed by those faults. Deformed and metamorphosed within Grenville Province. Krogh et al. (1987); Dudas, Davidson and Bethune (1994).***
Emplacement age of Mulock batholith	***1244+4/-3, 1250+10/-6***	***Lumbers et al. (1991); Davidson and van Breemen (2001)***
emplacement age of West Bay and Powassan batholiths	***~1235 and 1270±3***	***Heaman in Ketchum and Davidson (2000); Davidson and van Breemen (2001)***
Age of sedimentation within central Tomiko domain	1687±20	Krogh (1989)
Penokean metamorphism and deformation (effects may be minimal in Temagami area)	~1835 Ma	Holm et al. (2001)
Emplacement of Nipissing gabbro sills	2219±4 to 2210±4	Corfu and Andrews (1986); Noble and Lightfoot (1992)
Huronian sedimentation	>2220 but <2460	
Huronian felsic volcanism and related metaplutonic rocks	2460±20	Corfu and Easton (2000)
Emplacement of East Bull Lake intrusive suite rocks, including the River Valley intrusion	2475±2	Heaman (unpublished data); Krogh, Davis and Corfu (1984)
High-grade Archean metamorphism and pegmatite emplacement	2650±4	Krogh (1994); Krogh and Davis (1970)
Emplacement age of Ingall Lake batholith which is cut by Grenville Front	2736±2	Bowins and Heaman (1991)
Emplacement age of Archean metavolcanic rocks in the Temagami greenstone belt	2736±3	Bowins and Heaman (1991)

GRENVILLE FRONT TECTONIC ZONE

The Grenville Front tectonic zone in the region appears to consist mainly of Archean rocks that were metamorphosed and deformed during the Grenville Orogeny. These rocks include gneissic granodiorite of the Ingall Lake batholith and heterogeneous, granular gneiss of the Red Cedar Lake gneiss (Lumbers 1978; Easton 1992). Previous workers, such as Lumbers (1978), regarded the Red Cedar Lake gneiss as a metamorphosed and deformed equivalent of Archean metasedimentary rocks within the Pontiac Subprovince of the Superior Province. To the southwest, in the River Valley area, Easton (2000) reported geochemical data from the Red Cedar Lake gneiss that support the interpretation that the gneiss has been derived from Archean metasedimentary rocks. Analysis of regional U/Pb zircon ages led Easton (2000) to suggest that the Red Cedar Lake gneiss was not likely correlative with rocks of the Pontiac Subprovince, but represented a separate metasedimentary sequence. Deformed pegmatite dikes, in the Red Cedar Lake gneiss in the Grenville Front tectonic zone near Highway 11, yield zircon ages circa 2650 to 2660 Ma (Krogh and Davis 1970; Krogh 1994) confirming the Archean age of the Red Cedar Lake gneiss near the study area.

GRENVILLE PROVINCE, CENTRAL GNEISS BELT, TOMIKO DOMAIN

The study area straddles the boundary between the Grenville Front tectonic zone and the Tomiko domain. The Tomiko domain is one of several lithotectonic domains that comprise the Central Gneiss Belt of the Grenville Province. Easton (1992) separated the Tomiko domain from other domains in the Sudbury to North Bay area because of the presence of

- an abundance of paragneiss, including quartz arenites and iron formation, within the domain. The quartz arenites contain a restricted zircon population consisting only of Mesoproterozoic zircons (1687 ± 20 Ma, reported in Krogh 1989).
- Archean and Mesoproterozoic Nd/Sm model ages within the domain (e.g., Holmden and Dickin 1995) in contrast to adjacent domains containing mainly Archean Nd/Sm model ages.
- relatively young (circa 1245 Ma, *see* Table 1) granitoid rocks in the domain.
- indications of a distinct metamorphic history based on the presence of lower peak metamorphic temperatures and pressures recorded within the domain (Annovitz and Essene 1990).

The results of the present study indicate that the location of the boundary between the Grenville Front tectonic zone and the Tomiko domain was correctly interpreted in 1992 (Easton 1992). In addition, the boundary separates rocks of the Red Cedar Lake gneiss (Archean) in the north from a distinct package of rocks, likely of Proterozoic age, in the south (*see* Figures 1 and 2). The bounding shear zone was not observed, however, in large part due to poor exposure. It is also possible that the bounding shear zone may be relatively narrow which would also limit its exposure.

NEW GEOCHRONOLOGICAL RESULTS

A bulk sample was collected from each mafic intrusion for the purposes of determining the age of each body. Sample 01-RME-0121 was collected, using a helicopter for access, from a large ridge of leucotroctolite located in the northeast part of the Fall Lake intrusion. Sample 01-RME-0180 was collected, using a canoe for access, from a shoreline exposure of leucotroctolite on north-central Fanny Lake. Both samples were analyzed for whole rock and mineral chemistry with location data and other details provided in Appendixes 1 and 2. Both samples were processed for geochronology, largely because sample 01-RME-0121 showed little evidence, in thin section, of metamorphic recrystallization whereas sample 01-RME-0180 showed development of metamorphic coronas around olivine grains. These observations from thin sections are consistent with field observations that show that the Fanny Lake intrusion is metamorphosed to a greater extent than the Fall Lake intrusion. Both sets of observations suggest that there might be an age difference between the 2 bodies.

Geochronology was performed by J.W.F. Ketchum at the J. Satterly Geochronology Laboratory of the Royal Ontario Museum, Toronto, Ontario (Ketchum 2002). Only a synopsis of the preliminary geochronology results is included herein, full details will be reported at a later date.

The sample from the Fall Lake intrusion yielded pristine baddeleyite. Three single grains were concordant or just slightly discordant, with an average $^{207}Pb/^{206}Pb$ age of 1235 ± 2 Ma that is interpreted as the best estimate of the age of the intrusion. The sample from the Fanny Lake intrusion also contained baddeleyite grains, however, they had thin zircon overgrowths which were abraded off. The presence of zircon overgrowths on baddeleyite has been previously noted from mafic intrusions affected by Grenvillian metamorphism (e.g., Dudas, Davidson and Bethune 1994) and is consistent with the widespread development of corona textures around other minerals in the rock. Results from the Fanny Lake intrusion, based on the 2 most concordant grains, yield an average $^{207}Pb/^{206}Pb$ age of 1238 ± 2 Ma, which is interpreted as the best estimate of the age of the Fanny Lake intrusion (Ketchum 2002). This result is interesting, in that it suggests that there may be a small, but distinct, age difference between the Fanny Lake and Fall Lake intrusions, even though the ages do overlap slightly within uncertainty. The slightly older age of the Fanny Lake intrusion is, however, consistent with the field evidence indicating that it is slightly more metamorphosed than the Fall Lake intrusion.

The preliminary data indicate that both intrusions are the same age, within error, and are similar in age to the Sudbury diabase dike swarm. In addition, the mafic intrusions are close in age to the Mulock batholith dated at 1244 Ma (*see* Table 1), located in northwest Tomiko domain. As illustrated in Figure 1 and Table 1, there is increasing evidence of significant bimodal magmatism at 1270 to 1235 Ma within the North Bay area of the Grenville Province in Ontario. One explanation for this magmatism is that it is related to a former mantle–plume located east of Mattawa, Ontario. This mantle–plume would be responsible not only for emplacement of the Sudbury dike swarm, but also the Flett Township intrusions, the Mulock, West Bay and Powassan plutons and possibly the Mercer gabbroic anorthosite body.

Geology

The tectonostratigraphic sequence present within the study area is summarized in Table 2, which is condensed from the legend on Map P.3452 (back pocket), but has been updated to reflect knowledge gained from U/Pb geochronology and geochemical data collected since publication of Map P.3452 in December 2001.

PRECAMBRIAN

Neoarchean

RED CEDAR LAKE GNEISS (UNIT 1) AND ASSOCIATED INTERMEDIATE TO FELSIC INTRUSIVE ROCKS (UNIT 2)

The area west of the Fanny Lake intrusion is underlain by rocks of the Red Cedar Lake gneiss (Lumbers 1978; Easton 1992) (*see* Figure 2; *see* Map P.3452, back pocket), a regionally extensive unit that crops out within the Grenville Front tectonic zone between River Valley and the Ottawa River (*see* Figure 1). The unit is highly flattened near the contact of the Fanny Lake intrusion, but exhibits a less intense flattening fabric to the west. The Red Cedar Lake gneiss consists mainly of a granular, granodioritic gneiss, that locally contains abundant inclusions of fine-grained quartzofeldspathic gneiss (metawacke). Regional structural fabrics are dominantly north striking. The Red Cedar Lake gneiss has been interpreted (Lumbers 1978; Easton 1992, 2000) as representing Neoarchean migmatitic greywackes and associated granodioritic intrusive rocks that have been overprinted by Grenvillian metamorphism.

Exposures along the shores of Fanny Lake consist mainly of highly flattened varieties of the Red Cedar Lake gneiss (unit 1d) characterized by elongate quartz and plagioclase; and ribbon-like compositional layering ranging in composition from diorite to granodiorite. Plagioclase in these rocks commonly appears as isolated, almost granular, grains. West of Fanny Lake, the unit shows more compositional variation, thicker layers and a greater range in structural orientations. Most common are rocks of unit 1b, a grey-weathering migmatitic gneiss with more than 20% of white-weathering granodioritic to tonalitic leucosome or intrusive component. In several localities, buff- to grey-weathering, migmatitic, biotite-quartz-plagioclase metawacke, with less than 20% granodioritic to tonalitic leucosome (unit 1a), is present. This attests to the metasedimentary origin of part of this unit. Locally, meta-arenite (unit 1c) enclaves are present in material of unit 1a.

Table 2. Tectonostratigraphic sequence present within Flett and Angus townships.

PHANEROZOIC

CENOZOIC

QUATERNARY (RECENT and PLEISTOCENE)

Lake, stream and swamp deposits. Glacial deposits; sand and gravel, clay and till.

UNCONFORMITY

PRECAMBRIAN

PROTEROZOIC

MESOPROTEROZOIC

HIGH-GRADE METAMORPHISM WITHIN THE GRENVILLE PROVINCE

Fanny Lake and Fall Lake Intrusions

Leucotroctolite and Related Rocks (unit 13)
Leucotroctolite exhibiting no indication in thin section of the presence of corona texture.

UNKNOWN CONTACT

Mafic Gneiss and Metamorphosed Gabbro derived from Leucotroctolite, Troctolite, Melatroctolite and Related Rocks (units 11, 12)
Amphibolite and mafic gneiss (derived from melagabbro, gabbro), locally garnet bearing, both commonly strongly foliated and lineated. Hornblende gabbro and hornblende gabbronorite. Minor pyroxenite and amphibolite.

TECTONIC CONTACT

Leucotroctolite, Troctolite, Melatroctolite and Related Rocks (units 7, 8, 9)
Leucotroctolite and troctolite with variable development of corona texture around olivine, visible both in the field and in thin section. Locally containing centimetre- to decametre scale igneous layering defined by variation in olivine content, or the presence of alternating layers of melatroctolite, troctolite and leucotroctolite. Troctolite to melatroctolite, with varied development of magnetite-bearing alteration veins.

INTRUSIVE CONTACT

Felsic Intrusive Rocks (unit 6)
Fine- to medium-grained, granodiorite to monzogranitic gneiss.

INTRUSIVE CONTACT

Metasedimentary Rocks (unit 5)
Heterogeneous, matrix-supported metaconglomerate, interlayered with biotite-hornblende-quartz-plagioclase gneiss; matrix-supported, metaconglomerate dominated by granitoid clasts in a feldspathic matrix; clast-supported metaconglomerate dominated by granitic clasts in a feldspathic to granitic matrix and fine- to medium-grained muscovite-quartz schist to gneiss.

UNKNOWN CONTACT

PALEOPROTEROZOIC to NEOARCHEAN

Intermediate Intrusive Rocks (unit 4, 10)
Medium-grained, biotite-hornblende diorite gneiss.

INTRUSIVE CONTACT

Mafic Gneiss (unit 3)
Dark grey to black weathering, amphibolite and mafic gneiss (derived from melagabbro, gabbro) and grey weathering, amphibolite and mafic gneiss, locally garnet bearing (derived from gabbro, leucogabbro), both commonly strongly foliated and lineated.

TECTONIC CONTACT

ARCHEAN

NEOARCHEAN

REGIONAL HIGH-GRADE METAMORPHISM and MIGMATIZATION

Red Cedar Lake Gneiss and Associated Intermediate Intrusive Rocks (unit 1, 2)
Buff to grey weathering, migmatitic biotite-quartz-plagioclase metawacke, with varying amounts of granodioritic to tonalitic leucosome or intrusive material and grey to pink weathering, fine- to medium-grained, granodiorite to monzogranitic gneiss.

Associated with the Red Cedar Lake gneiss are larger masses of grey- to pale pink-weathering, fine- to medium-grained, migmatitic, granodioritic gneiss (unit 2) that resembles the leucosome phase of the Red Cedar Lake gneiss in outcrops. The granodioritic gneisses may represent larger masses of partial melt within the Red Cedar Lake gneiss; or may be phases of plutonic masses that intruded the paragneiss phase (unit 1) during the migmatization event that let to its current character. Similar plutonic masses occur in association with the Red Cedar Lake gneiss in the River Valley area (Easton 1999), consequently, their presence in this area is not unusual.

Rocks of unit 1 and 2 were not examined in thin section and were not sampled for geochemical analysis. As noted previously, near Highway 11, rocks assigned to the Red Cedar Lake gneiss are intruded by pegmatite dikes that are about 2650 Ma in age (Krogh 1994), hence the assignment of a Neoarchean age to units 1 and 2.

Paleoproterozoic to Neoarchean

MAFIC GNEISS (UNIT 3)

Medium-grained, grey- to dark-grey to black-weathering, amphibolite and mafic gneiss occur in a north-trending belt that extends through the centre of Fall Lake; along the northeastern margin of the Fall Lake intrusion; and as a small outlier engulfed by granitic gneiss west of Fall Lake. Four subunits are shown on Map P.3452 (back pocket). Map unit 3a consists of more melanocratic varieties (originally pyroxenite, melagabbro), whereas map unit 3b consists of slightly more leucocratic varieties (originally gabbro, leucogabbro) (Photo 1). Unit 3c is a variant of unit 3a, located along the northeast contact of the Fall Lake intrusion, that is characterized by the presence of secondary, elongate mineral grains that are most likely plagioclase (Photo 2). Unit 3d represents interlayered varieties of unit 3a and 3b, which are most common north of Fall Lake. The observed compositional layering in these rocks possibly represents original igneous layering (*see* Photo 1).

Sample 01-RME-0032, an example of mafic gneiss (unit 3a) from Fall Lake, contains green to dark green hornblende (40 to 45%) and a blue-green hornblende (10 to 15%). Other minerals in the samples are green and brown to dark brown biotite (10 to 15%), garnet (10%) and plagioclase (35 to 40%). Minor quartz, apatite and opaque grains are also present. Sample 01-RME-0033, an example of leucocratic mafic gneiss (unit 3b) from Fall Lake, is similar to the previously described sample since it contains 2 varieties of amphibole and biotite (40 to 45%, and 10%, respectively), garnet (5%) and plagioclase (50%) with minor apatite and opaque minerals. Sample 01-RME-0058, a sample of mafic gneiss (unit 3a) from the outlier west of Fall Lake, is similar to the previously described sample and contains 2 varieties of hornblende (50 to 55%), brown biotite (<3%), garnet (5 to 7%) and plagioclase (40 to 45%) with minor amounts of opaque minerals. In all 3 samples, the gneissic fabric is defined by the orientation of hornblende (both types) and plagioclase. Garnet grains are small and evenly distributed. In all 3 samples, brown biotite is the last mineral species to have developed, generally being lath-like, randomly oriented and most abundant in the plagioclase-rich portions of the samples.

Samples 01-RME-0127 and 01-RME-0128 are examples of unit 3c. Mineralogy consists of green and blue-green amphibole (40 to 45%), plagioclase (40 to 45%), garnet (10 to 15%), randomly oriented laths of brown biotite (10%), minor titanite, apatite and opaque minerals. In both samples, the gneissic fabric is defined by the orientation of hornblende (both types) and plagioclase. Texturally, sample 01-RME-0128 differs from sample 01-RME-0127, and the other samples described above, in that most of the amphibole consists of fine-grained radiating aggregates that likely represent a secondary recrystallization texture that formed after the development of the main metamorphic and gneissic fabric. In hand sample, both samples contain 0.5 to 3 cm long laths of plagioclase that are randomly oriented with respect to the

Photo 1. Probable igneous layering present in mafic gneisses (unit 3d) near the south-central contact of the Fall Lake intrusion. Hammer handle is 30 cm long.

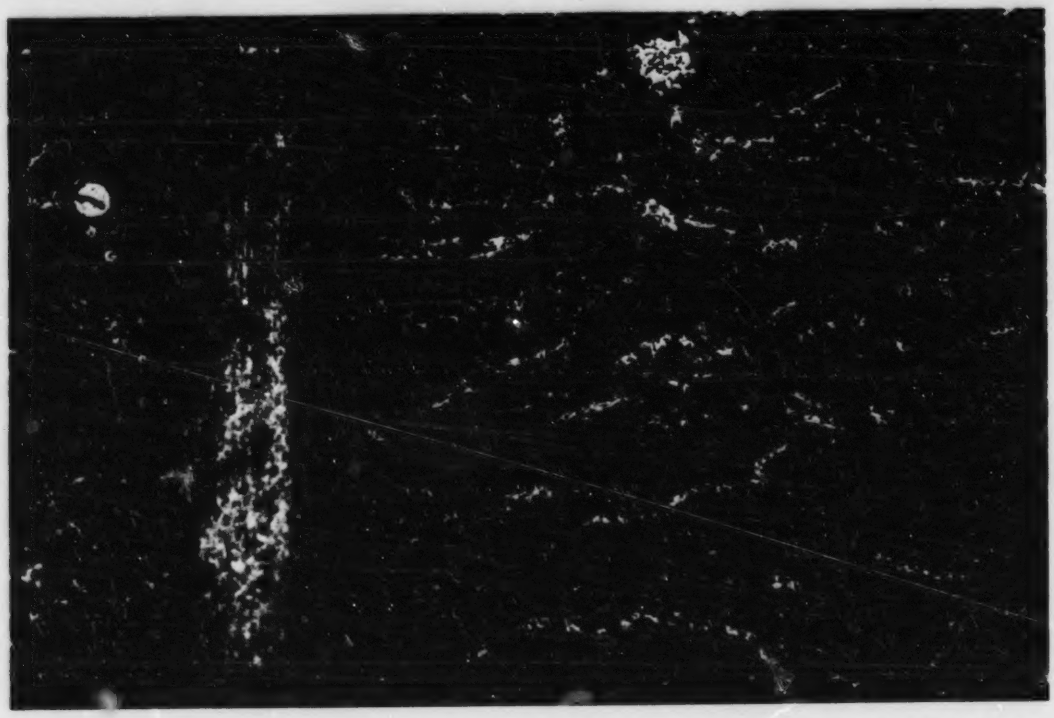

Photo 2. Development of large secondary plagioclase laths (shown by arrows) in mafic gneiss (unit 3c) located within 10 m of the contact of the Fall Lake intrusion. Hammer handle is 30 cm long.

gneissic fabric (*see* Photo 2). In thin section, these laths are not single plagioclase laths, but consist of an aggregate of small, anhedral plagioclase and garnet grains and small, randomly oriented laths of brown biotite. Most of the biotite in these samples is located in what were once larger plagioclase grains. In the field, it was speculated that these grains may have originally been scapolite, based on their form. In thin section, it is clear that the original mineralogy is no longer preserved and, if these were scapolite grains, they now consist of aggregates of garnet-biotite-plagioclase.

Mineral chemistry on samples 01-RME-0127 and 01-RME-0128 (*see* Appendix 2) indicate that there is no significant chemical difference between the 2 optically observed hornblende types. Both are ferrohornblende. Both samples also contain some grains of grünerite. Plagioclase composition is oligioclase, with values of An_{22-25} and An_{25-26} for samples 01-RME-0127 and 01-RME-0128, respectively. No compositional difference was noted between groundmass plagioclase and plagioclase present within the recrystallized plagioclase laths. Garnet in both samples is almandine with compositions of $Alm_{70-72}Prp_{11-16}Grs_{10-12}Sps_{2-3}$.

Geochemical data for 3 samples of mafic gneiss from unit 3 are listed in Appendix 1 and summarized in Figures 3a and 3b. The samples plot as high iron tholeiites on a Jensen diagram (*see* Figure 3a) or on the Irvine and Baragar (1971) AFM diagram (not shown). The chemistry of the mafic gneiss samples is fairly similar, and the 3 samples exhibit very similar chondrite-normalized rare earth element patterns (*see* Figure 3b). One sample of mafic gneiss derived from the Fanny Lake intrusion (unit 12) is also shown in Figure 3b and is difficult to distinguish from the other mafic gneiss samples on the basis of chemistry alone.

Lumbers (1971a) mapped the mafic gneisses of unit 3 as a deformed equivalent of the Fall Lake intrusion and included them in his anorthosite suite of rocks. Easton (2001; this study), regarded rocks of unit 3 as being significantly older than the Fall Lake intrusion. This interpretation is based on observations made north of Fall Lake where compositionally layered mafic gneiss of unit 3d is folded and truncated at the contact with leucotroctolite of the Fall Lake intrusion. This relationship indicates that unit 3 is older than unit 13, and likely older than units 7 to 13 collectively. In addition, even the recrystallized portions of the Fall Lake intrusion (unit 11h) are better preserved than even the least deformed equivalents of unit 3. In fact, rocks of unit 3 resemble the gneissic equivalents of the River Valley intrusion of the East Bull Lake intrusive suite located to the west along the Grenville Front (Easton 1999). However, the chemistry of the 4 analyzed samples of the unit 3 rocks present a conundrum. Samples 01-RME-0032, 01-RME-0033 and 01-RME-0128 (*see* Appendix 1) contain elevated Ba, TiO_2 and P_2O_5 contents and have chondrite-normalized rare earth element patterns (*see* Figure 3b) similar to those found in samples of the Fanny Lake intrusion. Sample 01-RME-0058 (*see* Appendix 1) shows a few differences from the other unit 3 samples, most notably higher Cr and lower Ba and Zr contents, but is otherwise broadly similar in composition. Elevated alkali contents in all of the 4 samples, as well as the observed late development of biotite, could be attributed to a regional alkali metasomatic event perhaps linked to the emplacement of the Fanny Lake and Fall Lake intrusions. This would be consistent with similar geochemical anomalies present in gneisses of unit 4, as described in "Intermediate Intrusive Rocks (Unit 4)". A metasomatic event would not necessarily explain the TiO_2 and P_2O_5 contents in the samples, however, unless the metasomatism was pervasive and multi-element in character. The possibility that rocks of unit 3 are indeed coeval with the Fall Lake intrusion, similar to mafic gneisses of unit 12 in the Fanny Lake intrusion, is not compelling given the field observations previously noted above. An alternative explanation, which is currently preferred, is that the mantle source region for the magmas for units 3, 4, and 7 to 13 was enriched in Ba, TiO_2 and P_2O_5 , and that this source was tapped at 2 or more separate times in order to generate rock units 3, 4, and 7 to 13.

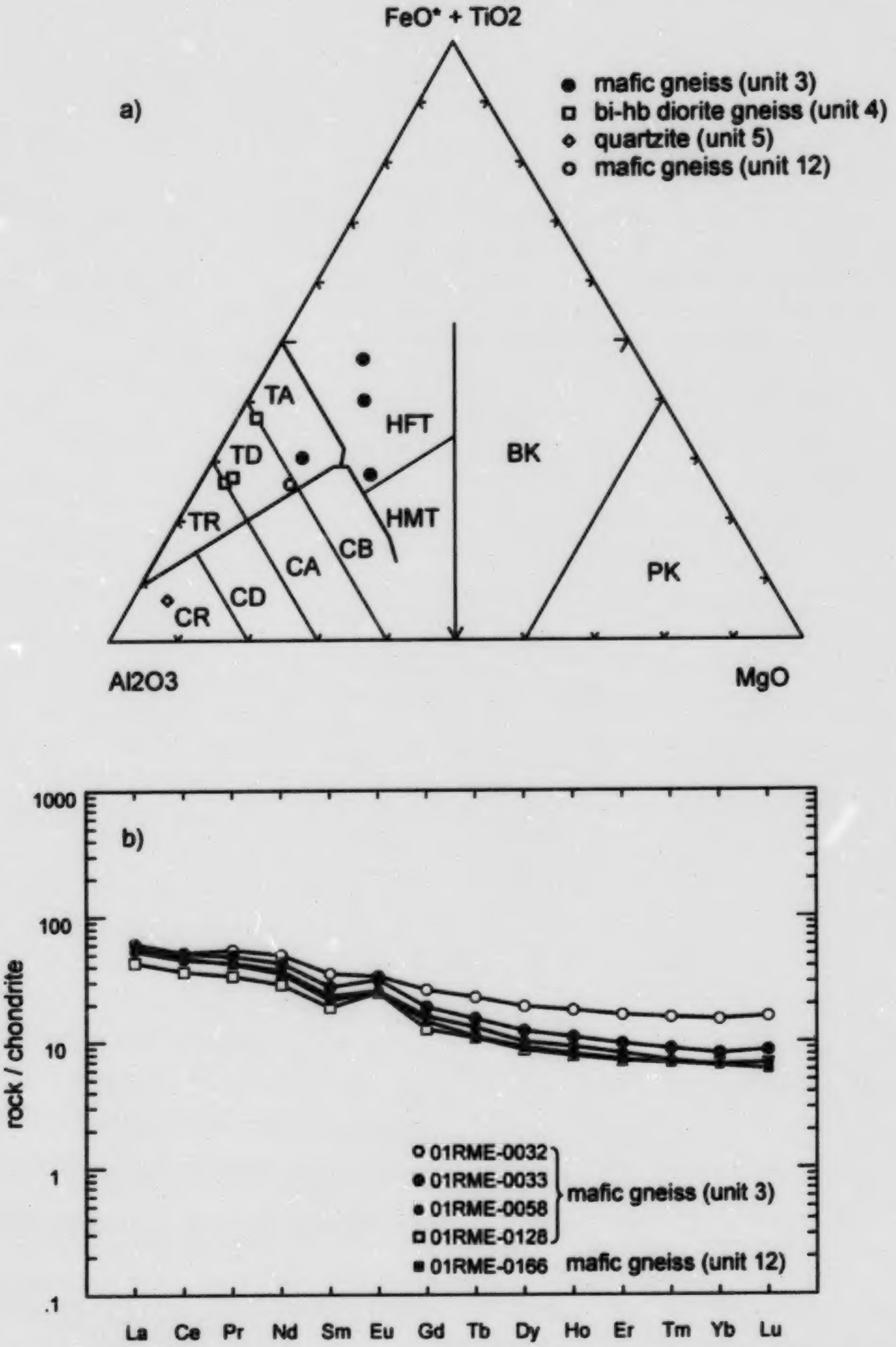

Figure 3. Geochemical features of country rocks to the Fanny Lake and Fall Lake intrusions. **a)** Jensen diagram for samples of mafic gneiss (unit 3 and unit 12), biotite-hornblende diorite gneiss (unit 4), and quartzite of unit 5. **b)** Chondrite-normalized rare earth element patterns for mafic gneiss of unit 3 and unit 12. All data are listed in Appendix 1.

INTERMEDIATE INTRUSIVE ROCKS (UNIT 4)

Medium-grained, biotite-hornblende diorite gneiss (unit 4) occurs in 2 north-trending belts, one located on the west shore of Fall Lake, the other located on the northwest arm of Fanny Lake. Both are bounded to the east by belts of mafic gneiss belonging to either unit 3 or 12, respectively. The relative age of the biotite-hornblende diorite gneiss is difficult to ascertain, although west of Fanny Lake it is apparently cut by gneissic granite (unit 6). The intense deformation in the biotite-hornblende diorite gneiss, and the complicated growth history exhibited by the mafic minerals present in this unit (as outlined below), are consistent with the biotite-hornblende diorite gneiss being one of the older rock units present in the area.

The rock is buff black-weathering on weathered surfaces and is white to black to buff black on fresh surfaces. It forms well-rounded, glacially polished outcrops from which it is difficult to obtain fresh samples. The rock itself is quite friable due in part to weathering along the grain boundaries between the felsic and mafic minerals.

Thin sections of biotite-hornblende diorite gneiss from both belts are remarkably similar. Sample 01-RME-0046, from Fall Lake, contains 10 to 15% clinopyroxene, 10 to 15% green hornblende, 10 to 15% brown and greenish biotite, 60% plagioclase, 5 to 10% potassium feldspar and 3 to 5% titanite plus minor apatite. Sample 01-RME-00170, from Fanny Lake, differs only in that it contains slightly more clinopyroxene (30%), little potassium feldspar and only brown biotite. Both samples exhibit a strong fabric due to orientation of plagioclase and biotite grains. Both samples also exhibit a similar paragenetic sequence for the mafic minerals consisting (from oldest to youngest) of clinopyroxene, hornblende and biotite. Clinopyroxene is usually present as partly retrograded cores surrounded by green hornblende, which is also retrograded to secondary biotite. Lath-like biotite has developed late around the earlier formed clinopyroxene and hornblende grains and shows a partially random orientation. The high abundance of titanite and apatite in these rocks is consistent with elevated TiO_2 and P_2O_5 contents observed in the major element chemistry (*see* samples 01-RME-0046 and 01-RME-0170, Appendix 1).

An outcrop (sample 01-RME-0008, *see* Appendix 1), found on the north side of a small island in Fall Lake, which on Map P.3452 (back pocket) is shown as belonging to unit 10—medium- to coarse-grained Sudbury swarm diabase dike—may instead be a less recrystallized equivalent of unit 4. This would be consistent with the fact that rocks more typical of unit 4 make up the southern part of the same island. In addition, the major, trace and rare earth element chemistry of this unit (sample 01-RME-0008; Figure 4; *see* Appendix 1) is nearly identically to that of unit 4 (sample 01-RME-0046; *see* Figure 4; *see* Appendix 1). In thin section, sample 01-RME-0008 contains 15 to 20% clinopyroxene, 10 to 15% green hornblende, 10 to 15% brown biotite, 60% plagioclase, 5 to 10% potassium feldspar and 3 to 5% titanite plus minor apatite. Biotite occurs either in radiating clusters that may represent a replacement of pre-existing mafic minerals or marginal to clusters of clinopyroxene and green amphibole. The amphibole occurs as a fine-grained aggregate of grains, possibly including green spinel, likely representing the replacement of a pre-existing mineral. More significantly, the sample lacks preserved or altered olivine and does not contain abundant oxide minerals, both of which are typical mineralogical components of metamorphosed Sudbury diabase dikes in the Grenville Province.

Mineral chemistry on sample 01-RME-0008 (*see* Appendix 2) indicate alkali feldspar compositions of $Or_{88-91}Ab_{9-12}An_{0-0.3}$. Albite ($Ab_{98}$) locally rims alkali feldspar grains. Amphibole is mainly ferroactinolite although a few grains of grünerite were also observed.

It is unclear how these rocks (samples 01-RME-0008, 01-RME-0046, 01-RME-0170) relate to the Fanny Lake and Fall Lake intrusions. Many geochemical features, in particular the elevated Ba, TiO_2 and P_2O_5 contents (*see* Appendix 1) are consistent with a geochemical linkage to the mafic intrusions. For this to be the case, however, considerable fractionation of the mafic magma would need to have occurred in order to generate the observed SiO_2 content (56.2 to 57.2 weight %). Also, rock compositions that are intermediate between the most fractionated members of the mafic intrusions and the unit 4 samples have not been observed. As discussed in the previous section "Mafic Gneiss (Unit 3)", the high alkali contents and late development of brown biotite, could be attributed to a regional alkali metasomatic event linked to emplacement of the Fanny Lake and Fall Lake intrusions. Alternatively, the mantle source region for the magmas for units 3, 4, and 7 to 13 may simply be enriched in these elements. At present, the relationship of unit 4 to rocks of the mafic intrusions (units 7 to 13) remains enigmatic.

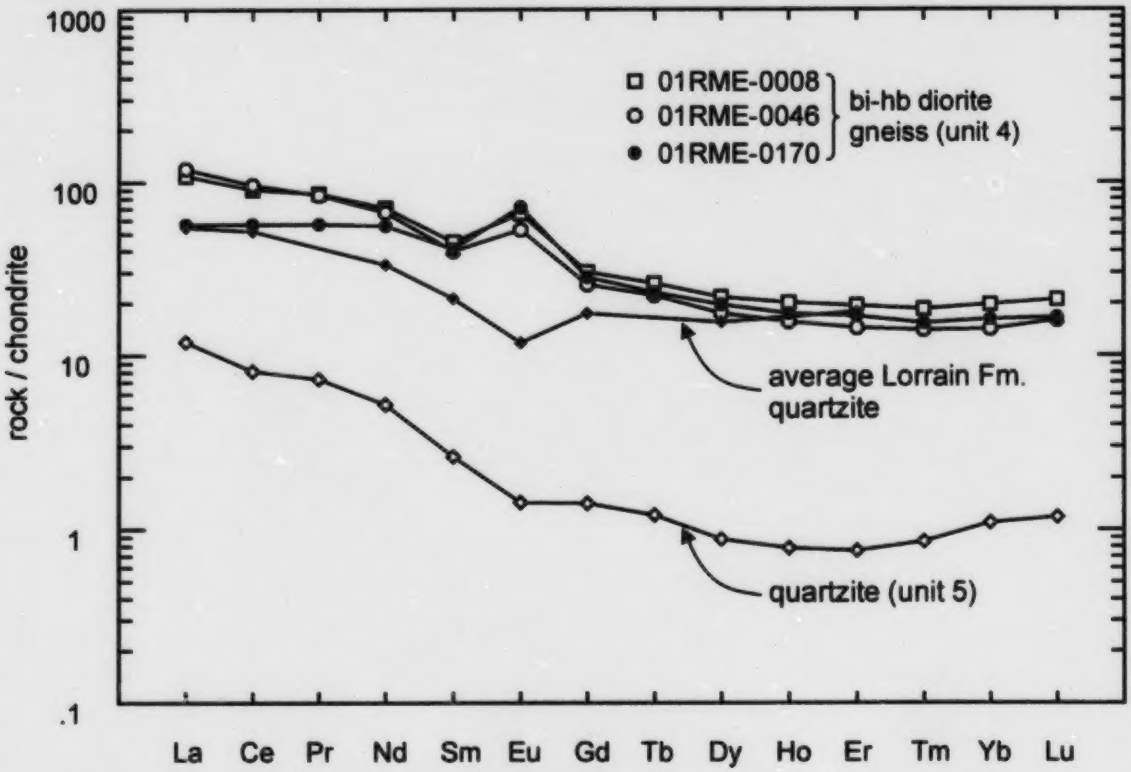

Figure 4. Chondrite-normalized rare earth element patterns illustrating nearly identical patterns for 3 samples of biotite-hornblende diorite gneiss (unit 4). Also plotted is an average of 4 Lorrain Formation quartzite samples from McLennan, Fryer and Young (1979) and a sample of quartzite of unit 5. Note the much higher total rare earth element content of the Lorrain Formation sample compared to the quartzite sample of unit 5. All data are listed in Appendix 1.

Paleoproterozoic to Mesoproterozoic

METASEDIMENTARY ROCKS (UNIT 5)

A previously undocumented, 1 km long belt of metaconglomerate was identified along the southern margin of the Fanny Lake intrusion (*see* Map P.3452, back pocket). Several varieties of metaconglomerate are present, including 1) a heterogeneous, matrix-supported metaconglomerate (unit 5a)(Photo 3); 2) a matrix-supported metaconglomerate dominated by granitoid clasts in a feldspathic matrix (unit 5b) (Photo 4); and 3) a clast-supported metaconglomerate dominated by granitic clasts that grades into adjacent gneissic granite of unit 6 (unit 5c). It is possible that the gradation in unit 5c represents a preserved unconformity; if so, it may indicate that parts of unit 5 are younger than unit 6. Elsewhere, however, quartzose schists of unit 5d and 5e are cut by granitic rocks of unit 6. It is possible that there are several ages of granitic rocks present within the study area.

Quartzose schists (unit 5d, 5e), that probably represent metamorphosed feldspathic arenites, occur south of Fanny Lake near the metaconglomerate belt and northwest of the Fall Lake intrusion (*see* Map P.3452, back pocket). The largest exposure occurs south of Fanny Lake where the quartzose schists (unit 5d) and metaconglomerates are not in contact with each other. It is possible that these rocks are part of the same sedimentary succession that has been variably intruded by younger granitic rocks. Exposures of quartzose schists, northwest of the Fall Lake intrusion, are limited in area and consist of layers or pods (unit 5e) within a larger mass of fine-grained granitic gneiss. It is possible that some of the granitic gneiss (unit 6) within the area represents metamorphosed feldspathic arenites, as suggested by Lumbers (1971a, 1971b, 1978), although this can not be reliably ascertained. Lumbers (1971a) indicated the presence of an area of quartzose metasedimentary rock south of Fall Lake, however, only granitic gneisses were located in this area during this study.

In the field and in thin section, there is little difference between the quartzose schists south of Fanny Lake and those found northwest of the Fall Lake intrusion. Both units 5d and 5e are white- to black-weathering on outcrop surfaces. The white colouration is present on bare, glaciated outcrops, whereas the black colouration occurs on more vegetated outcrops and is related to the presence of small, crustose lichens that grow along grain boundaries in the rock. Fresh surfaces are white to reddish-white and show a high percentage of variably altered white mica grains. Sample 01-RME-0150, collected from an outcrop located south of Fanny Lake, contains roughly 20% muscovite, 70% quartz, 5% plagioclase, 5% potassium feldspar and minor biotite, epidote and opaque minerals with quartz grains exhibiting a granulite texture. Sample 01-RME-0104, collected from an outcrop located northwest of the Fall Lake intrusion, contains 25 to 30% muscovite, 65% quartz, 5% potassium feldspar and minor plagioclase and opaque minerals. Sample 01-RME-0104 exhibits a schistose texture due to its higher muscovite content.

The age of the metaconglomerates and the quartzose schists is unknown. The metaconglomerate units could be correlative with the Coleman Member of the Gowganda Formation, with the quartzose schists being equivalent to the Lorrain Formation. Both these units crop out north of the Grenville Front, only 10 to 12 km to the north. However, potential Huronian Supergroup rocks have not been reported in the intervening Grenville Front tectonic zone, nor have they been documented elsewhere in Tomiko domain. Consequently, it is equally plausible that metasedimentary rocks of unit 5 are correlative with quartzite and related rocks of Geon 16 age, located approximately 20 km to the south-southeast in Tomiko domain.

Photo 3. Flattened matrix-supported metaconglomerate of unit 5a, southern Fanny Lake. Hammer handle is 30 cm long.

Photo 4. Flattened matrix-supported feldspathic metaconglomerate or metavolcanic breccia of unit 5b, southern Fanny Lake. Hammer head is 18 cm long.

Sample 01-RME-0150 was analyzed for major, trace and rare earth element chemistry (*see* Appendix 1) to test the possible correlation unit 5d with the Lorrain Formation. A considerable body of literature exists with respect to the geochemical signature of Huronian Supergroup rocks and each formation has distinctive chemical characteristics (e.g., McLennan, Fryer and Young 1979; Fedo, Young and Nesbitt 1997; Easton and Murphy 2002), particularly in their rare earth element contents. In this respect, the Lorrain Formation, at least in the Sault Ste. Marie to Sudbury area, is characterized by average total rare earth element contents of 115 ± 60 ppm and a positive Eu anomaly with an Eu/Eu* ratio of 0.63 ± 0.15 (*see* Figure 4). Samples from the Lorrain Formation from the Cobalt Plate (Rice 1991) appear to have similar chemistry. In contrast, sample 01-RME-0150 is distinctly different, having a total rare earth element content of 17 ppm (*see* Figure 4), a Eu/Eu* ratio of 0.95, 2 ppm Y, 16 ppm Cr, and a U/Th ratio of 0.13. These data suggest that the rock unit represented by sample 01-RME-0150 is not correlative with the Lorrain Formation. Unfortunately, no published chemical data presently exist for the Tomiko domain quartz arenites that would allow testing of their potential correlation with unit 5d.

Mesoproterozoic

FELSIC INTRUSIVE ROCKS (UNIT 6)

Pink- to grey-weathering, fine- to medium-grained, granodiorite to monzogranite gneiss form most of the country rocks to the Fanny Lake and Fall Lake intrusions (Map P.3452, back pocket). Two main varieties are recognized: 1) unit 6a, consisting of pink- to grey-weathering, fine- to medium-grained, granodiorite to monzogranite gneiss; and 2) unit 6b, pink-weathering, fine- to medium-grained, monzogranite gneiss. Although gneissic, these rocks show very little obvious compositional layering within individual outcrops.

In the Fall Lake area, rocks of unit 6 contain a different set of inclusions depending on whether they are located west or east of Fall Lake. West of Fall Lake, inclusions consist of thin layers or screens of grey, migmatitic, quartzofeldspathic gneiss and minor amphibolite (unit 6c). In a single outcrop, on the northwest shore of Fall Lake, rafts of dark green weathering hornblendite (unit 6d) were observed within granitic gneiss of unit 6. In contrast, east of Fall Lake, inclusions and enclaves within unit 6 consist of fine- to medium-grained granodiorite to monzogranite gneiss as well as fine-grained biotite diorite, biotite granodiorite and biotite diorite orthogneiss (unit 6e). Rocks of unit 6c occur west of the north-trending belt of unit 3 and 4 rocks present in Fall Lake, whereas rocks of unit 6e occur east of this belt. This change in inclusion type, across the north-trending belt of unit 3 and 4 rocks, suggests that the granitic rocks of unit 6 invaded two compositionally different domains present on either side of the belt. This further supports the field observations made earlier that rocks of unit 3 and 4 are older than units 7 to 13, and that rocks of unit 3 and 4 are intimately associated with the earlier structural history of the area. It also establishes that unit 6 represents the youngest Mesoproterozoic rocks in the study area.

Within the Grenville Front tectonic zone in the study area, pink-weathering, medium- to coarse-grained monzogranite to syenogranite gneiss (unit 6f) locally transect rocks of the Red Cedar Lake gneiss. Lumbers et al. (1991) correlated these granitic rocks (unit 6f) with the Mulock granite batholith for which they obtained an age of 1244 +4/−3 Ma. Rocks of unit 6f are included in unit 6 because of their granitic composition. This assignment does not necessarily imply that all the granitic rocks of units 6a to 6e are also correlative with the Mulock granite batholith.

Petrography and geochemistry were not conducted on rocks of unit 6. A thin section examined by Racicot and Keevil (1998), from a sample of unit 6e collected on the southeast shore of Fall Lake, consisted of potassium feldspar (40%), plagioclase (20%), quartz (20%), biotite (5%) and amphibole (5%) with minor oxide minerals.

MAFIC INTRUSIVE ROCKS (UNITS 7, 8, 9, 11, 12 AND 13)

Introduction

In this section, the Fanny Lake and Fall Lake intrusions are each described in turn, under the following categories: contact relationships; rock types and stratigraphy; and description of the map units present in each intrusion. This is followed by a combined discussion of the geochemistry of both intrusions.

The mafic intrusive rocks in the map area are divided into 7 units (*see* Map P.3452, back pocket). Units 7, 8, 9, 11 and 12 are assigned to the Fanny Lake intrusion; unit 10 occurred in a single outcrop and was interpreted in the field as a dike; and unit 13 was assigned exclusively to the Fall Lake intrusion. As noted in "Intermediate Intrusive Rocks (Unit 4)", rocks of unit 10 may simply be a better preserved example of the biotite-hornblende diorite gneiss of unit 4. Leucotroctolite of unit 13 is interpreted (on the basis that it is weakly metamorphosed) as possibly being the youngest unit in the area (*see* Map P.3452, back pocket). As noted previously in the section on "New Geochronological Results", rocks of unit 13 are slightly younger than leucotroctolite of unit 9, although the ages overlap within analytical uncertainty. The U/Pb data are consistent with the relative age relationships shown on Map P.3452 (back pocket), since rocks of unit 9 grade into more highly metamorphosed rocks of unit 11 and 12, suggesting emplacement before peak metamorphism and deformation. In contrast, rocks of unit 13 do not show this gradation and may have been emplaced during or after peak metamorphism and deformation.

Fanny Lake Intrusion

CONTACT RELATIONSHIPS

A northeast-striking shear zone consisting of mafic gneiss (unit 12) is exposed on islands in Breadalbane Lake and divides the Fanny Lake intrusion into a northwest body (*see* Figure 2) and a main body. This shear zone may connect with a major north-northeast-trending deformation zone that is parallel to Wickstead Lake, southwest of the study area. The flattening fabric observed in the Red Cedar Lake gneiss (unit 1d) may also be a manifestation of this shear zone. The intrusion is best exposed along the shores of Fanny and McDiarmid lakes and in the northern half of the northwest body.

Country rocks and mafic intrusive rocks of the Fanny Lake intrusion occur within a few metres of each other in many parts of the map area, however, contacts were not observed. Relatively sharp contacts, with no indication of shearing, and only minor recrystallization of the mafic intrusive rocks are present along the northern margin of the northwest body and the northeast margin of the main body. Contacts in these areas likely represent preserved intrusive contacts (*see* Figure 2). In contrast, the northern, southern and western margins of the main body of the Fanny Lake intrusion consist of 1) an inner rim—tens to hundreds of metres thick—of recrystallized gabbro (unit 11)(dominated by fine-grained amphibole and plagioclase); and 2) an outer rim—tens to hundreds of metres thick—of mafic gneiss (unit 12), typically strongly lineated and locally garnet-bearing (*see* Figure 2; *see* Map P.3452, back pocket). The interior of the main body is relatively undeformed and exhibits very few outcrop-scale shear zones although it is deformed and recrystallized along its margins. In addition, the mafic intrusive rocks show no indication of increased deformation adjacent to topographic lows or lineaments.

ROCK TYPES AND STRATIGRAPHY

Overview

Five main rock types, all variably metamorphosed, are present in the Fanny Lake intrusion (*see* Map P.3452, back pocket; *see* Table 2). As noted above, the recrystallized gabbro (unit 11) and mafic gneiss (unit 12) occur within the margin of the body and were likely derived from the other 3 rock types (units 7, 8, and 9). These other 3 rock types contain preserved igneous textures and layering, however, olivine and/or orthopyroxene are rimmed by coronas of secondary minerals that are an effect of regional metamorphism. Leucotroctolite (unit 9) accounts for roughly 40% of the surface area of the intrusion with troctolite (unit 8) and melatroctolite (unit 7) each accounting for another 20%. Troctolitic rocks (unit 8) typically contain minor amounts of pyroxene (<10%). Some of the melatroctolites approach dunite in composition (i.e., <10% plagioclase), but are dominated by magnetite, not chromite, as the oxide mineral. Brecciated, gossanous or sulphidic rocks were not observed within the Fanny Lake intrusion during this study.

In the main body, compositional layering (50 to 250 m thick) is defined by variation in olivine content. In some layers, mineral grading or cross-bedding provide some indication of facing direction. In the main body, this layering is oriented between 180 to 200° and is generally steeply west dipping and west facing (Photo 5). Limited measurements from the poorly exposed eastern part of the main body indicates a reversal in dip to the east (*see* Map P.3452, back pocket) which could indicate that layering is

Photo 5. Decametre-scale, north-trending, igneous layering in the Fanny Lake intrusion, northern McDiarmid Lake. View to the south, grading suggests facing to the east (right). Hammer handle is 30 cm long.

folded about a north-trending anticline. If the intrusion is not folded, then roughly 1 km of stratigraphy is exposed in the body, consisting, from west to east, of the following sequence:

>150 m	troctolite
75 to 250 m	leucotroctolite, layered
75 m	melatroctolite, strongly veined and/or foliated
150 m	leucotroctolite
75 m	melatroctolite, strongly veined
75 to 150 m	leucotroctolite, layered
75 to 150 m	melatroctolite, foliated
150 m	leucotroctolite
75 to 100 m	melatroctolite, foliated
>250 m	leucotroctolite

In addition to west to east variation, there may also be thickening, thinning and interdigitation of layers in a north to south direction (*see* Map P.3452, back pocket). It is not possible to reliably determine the top or bottom of the intrusion, however, if the intrusion is not folded, then the few facing directions would suggest that the eastern contact of the intrusion might be the base of the main body. If the intrusion is folded, then the olivine-rich rocks at McDiarmid Lake and eastern Fanny Lake would represent the basal part of the intrusion.

The northwest body consists mainly of leucotroctolite with minor troctolite and melatroctolite. Layering in the northwest body is also defined by variation in olivine content, however, layers are thinner (decametre to metre scale) than those observed in the main body. The trend of the layering suggests folding about a northeast-trending synform (*see* Map P.3452, back pocket).

Melatroctolite and Related Rocks (Unit 7)

Unit 7 consists of melatroctolites (unit 7a) that contain visible plagioclase and olivinites and plagioclase-poor melatroctolites (unit 7b) that do not contain visible plagioclase. The term olivinite is used instead of dunite because the dominant spinel mineral in these rocks is magnetite and not chromite. Melatroctolites tend to be brown to dark brown weathering in outcrop, dark brown on fresh surface, and typically contain a pronounced fabric parallel to stratigraphic layering in the intrusion (Photo 6). This fabric is north-striking in the main body of the Fanny Lake intrusion.

Olivinites tend to be dark-brown to dark-grey weathering rocks. Fresh surfaces are dark grey and greasy in appearance. Both units are cut by alteration veins, however, these are more abundant in olivinite outcrops. The alteration veins consist of fine-grained, white to black and orange rock (mainly composed of iddingsite) containing layers and pods of medium-grained magnetite (Photo 7). Alteration vein density can vary from less than 15% of the outcrop surface to more than 50%. The veins are always more oxide rich than the host melatroctolite. With increasing abundance, these veinlets become increasingly interconnected and develop a planar orientation, which likely corresponds to the planar fabric observed in many outcrops (*see* Photo 6). Unit 7c (*see* Map P.3452, back pocket) identifies outcrops that contain abundant veins. Previously noted iron occurrences in the Fanny Lake intrusion (Lumbers 1971a) are located in these melatroctolite layers, and most likely correspond to areas of more intense alteration.

Several samples of this unit were examined in thin section. The melatroctolites contain roughly equal amounts of olivine and plagioclase whereas the olivinites and plagioclase-poor melatroctolites contain between 75 to 90% olivine and 25 to 10% plagioclase. In the case of the melatroctolites, the samples generally exhibit a fabric, recognized in thin section, which is defined by the elongation of plagioclase and olivine (with some of the olivine showing an elongate habit). It is not known if this is a preserved magmatic texture or whether it is tectonic in origin, however, the limited degree of olivine alteration and the elongate habit of many olivine grains, suggest that it may be a primary igneous texture.

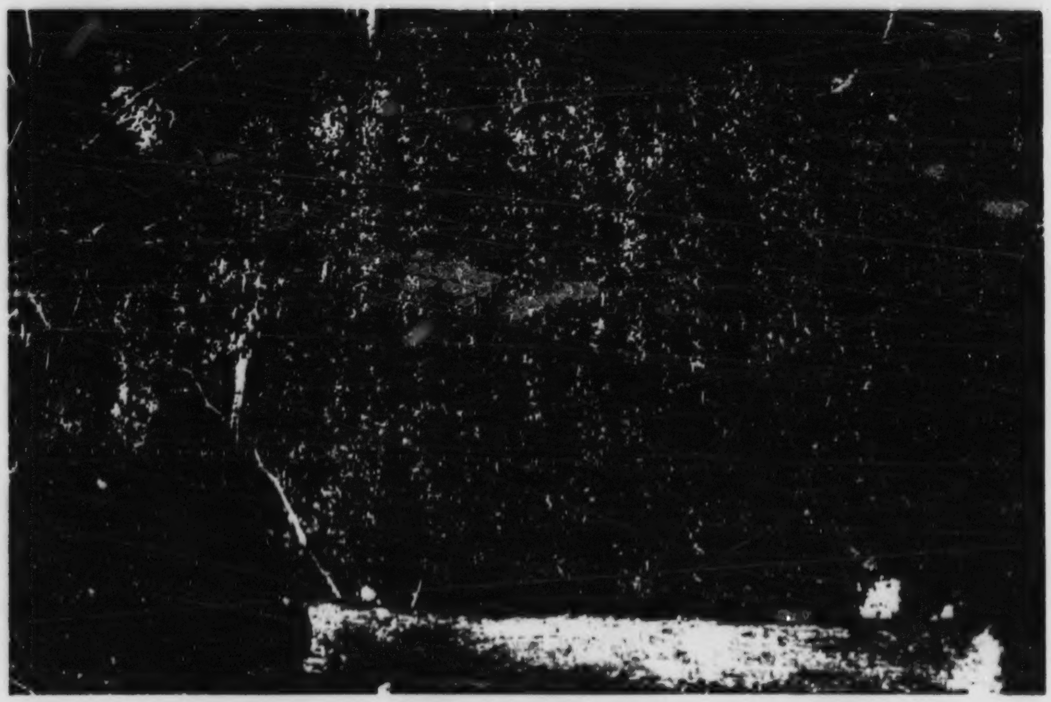

Photo 6. Brown-weathering melatroctolite (unit 7). Fabric in rock is defined by thin alteration zones (light brown) in the rock. Fanny Lake intrusion, northeastern Fanny Lake. Hammer handle is 30 cm long.

Photo 7. Alteration veins consisting of magnetite and iron-rich clay minerals within melatroctolite (unit 7) of the Fanny Lake intrusion, southern McDiarmid Lake. Hammer handle is 30 cm long.

Troctolite and Related Rocks (Unit 8)

Unit 8 was defined on the basis of containing 2 mafic minerals (generally clinopyroxene and olivine) and possessing a moderate colour index. Based on thin section examination, it is now clear that this unit consists of olivine gabbro rather than troctolite. Clinopyroxene content in these rocks is related to plagioclase content. Rocks within this unit grade from olivine norite to troctolite to leucotroctolite with increasing plagioclase content.

Several samples with primary igneous textures, but showing varying degrees of secondary corona development around olivine grains (Photos 8, 9 and 10), were studied in thin section. Clinopyroxene does not show corona development in samples whereas olivine is rimmed by narrow or incipient coronas (*see* Photo 9). The rocks are medium grained with the dominant primocryst phases being olivine (30 to 35%), light brown clinopyroxene (10 to 15%), plagioclase (60%) and minor biotite which is generally present around oxide minerals. Apatite is a common accessory mineral and may range between 1 to 5% in some samples (Photo 11). Apatite commonly shows an elongate habit and appears to have been one of the latest primary phases to develop in the rock.

Leucotroctolite and Related Rocks (Unit 9)

The bulk of the Fanny Lake intrusion (over 40%) consists of light grey- to grey-weathering, medium-grained leucotroctolite of unit 9a. It differs from leucotroctolite in the Fall Lake intrusion (unit 13) in that all samples of unit 9a show varied degrees of secondary corona development around olivine (visible in the field and in thin section). Two layered varieties of unit 9 are locally present. At the south end of McDiarmid Lake, a layered unit contains centimetre- to decametre-scale igneous layering defined by variation in olivine content (unit 9b, Photo 12). In the northwest mass, centimetre- to decametre-scale igneous layering is defined by alternating layers of melatroctolite, troctolite and leucotroctolite (unit 9c). Leucotroctolite shares many of the same mineralogical and textural characteristics of troctolite (*see* "Troctolite and Related Rocks (Unit 8)") except that it contains less clinopyroxene and apatite.

Two rock samples (01-RME-0191 and 01-RME-0307, *see* Appendix 2) are distinctly different from the troctolite. Sample 01-RME-0191 was collected from a pale green-weathering, fine- to medium-grained dike that intrudes troctolite of unit 8, whereas sample 01-RME-0307 was collected from a large outcrop of layered leucotroctolite (unit 9b). These 2 samples consist of roughly equal amounts of olivine and plagioclase, however, the olivine occurs as small, anhedral to subrounded grains distributed throughout the rocks (Photo 13). The olivine is generally oriented parallel to the fabric in the rocks that is defined by the orientation of plagioclase laths. This is in contrast to the other samples of troctolite (unit 8) and leucotroctolite (unit 9) wherein olivine (and clinopyroxene) occur as larger grains scattered throughout the rock.

Mineral Chemistry of the Mafic Intrusive Rocks (Units 7, 8 and 9)

Six samples were chosen for electron microprobe study. Five samples are in stratigraphic order and cover roughly 600 m of section. From the stratigraphically lowest to highest, they are samples 01-RME-0199, 01-RME-0195, 01-RME-0188, 01-RME-0190 and 01-RME-0180 (*see* Appendix 2). Sample 01-RME-0191 is from a dike that cuts rocks represented by sample 01-RME-0190. Neither olivine or plagioclase grains from any of the samples showed any significant difference in core and rim compositions suggesting the absence of growth related compositional zoning. Core compositions of olivine and plagioclase were more magnesium-rich (Fo_{65-70}) and calcic (An_{62-65}) in the melatroctolite samples than in the leucotroctolite and troctolite samples (Fo_{56-65} and An_{50-69}). Leucotroctolite and troctolite samples also contained diopside ($Wo_{45-47}En_{36-40}Fs_{13-16}$). Differences between individual samples of the same rock type, for example, leucotroctolite samples 01-RME-0188 and 01-RME-0180 (Fo_{58-65}, An_{54-69}, $Wo_{46-47}En_{40}Fs_{13-14}$) and ($Fo_{58-62}$, An_{50-63}, $Wo_{45}En_{39-40}Fs_{39-40}$), respectively, are within analytical error even

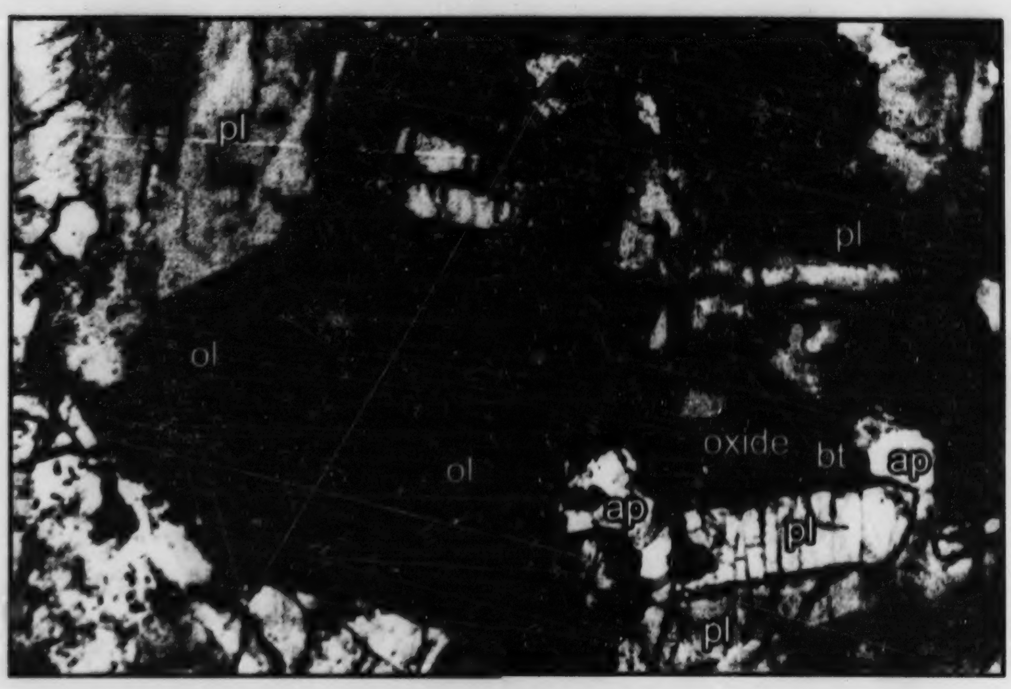

Photo 8. Photomicrograph of sample 01-RME-0121, leucotroctolite from the Fall Lake intrusion, showing little metamorphic corona development around olivine grains, as well as apatite grains. Field of view roughly 3.8 mm wide. Abbreviations: ap = apatite; bt = biotite, ol = olivine, pl = plagioclase.

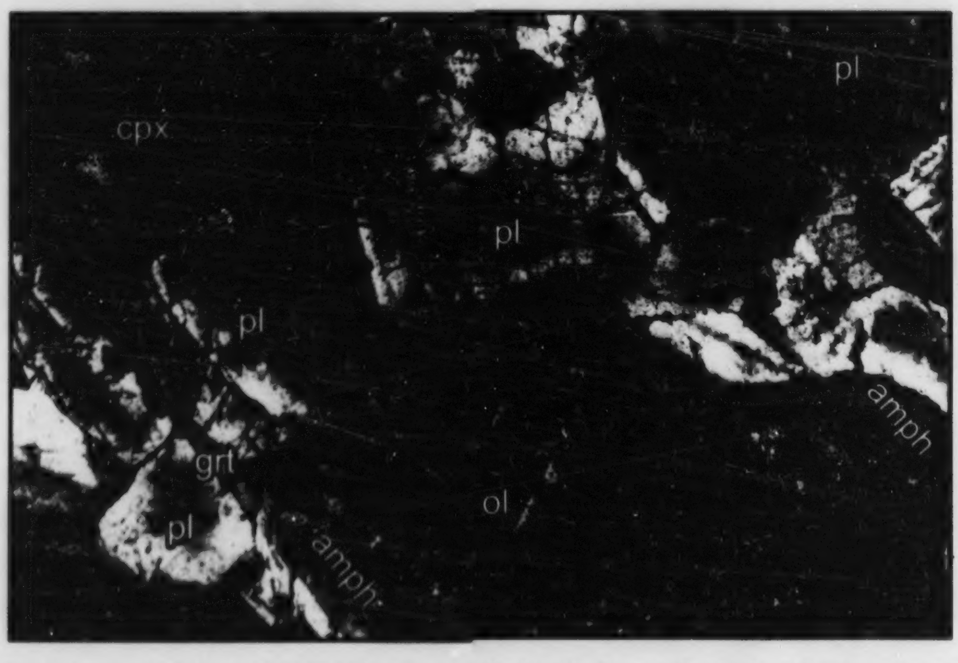

Photo 9. Photomicrograph of sample 01-RME-0188, leucotroctolite from the Fanny Lake intrusion, showing metamorphic corona, consisting of fine-grained amphibole and garnet, developed around olivine grains. Coronas locally contain small garnet grains. Field of view roughly 3.8 mm wide. Abbreviations: amph = amphibole, cpx = augite; grt = garnet, ol = olivine, pl = plagioclase.

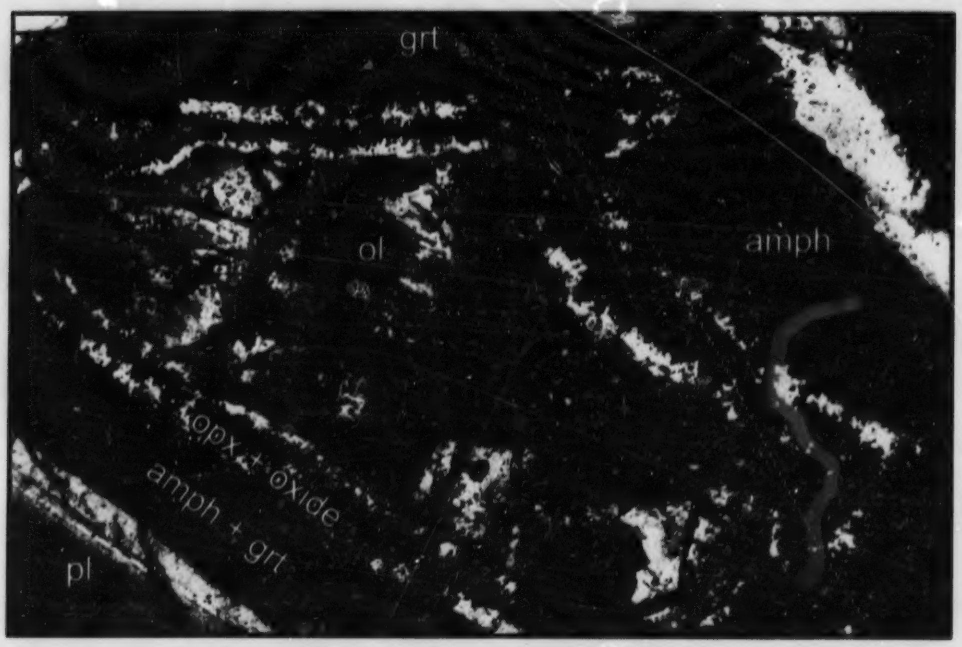

Photo 10. Photomicrograph of sample 01-RME-0192, leucotroctolite from the Fall Lake intrusion, showing 2 metamorphic coronas developed around olivine grains. Inner corona consists of orthopyroxene and oxide grains. Outer corona consists of amphibole and garnet grains. Field of view roughly 3.8 mm wide. Abbreviations: amph = amphibole, grt = garnet, ol = olivine, pl = plagioclase.

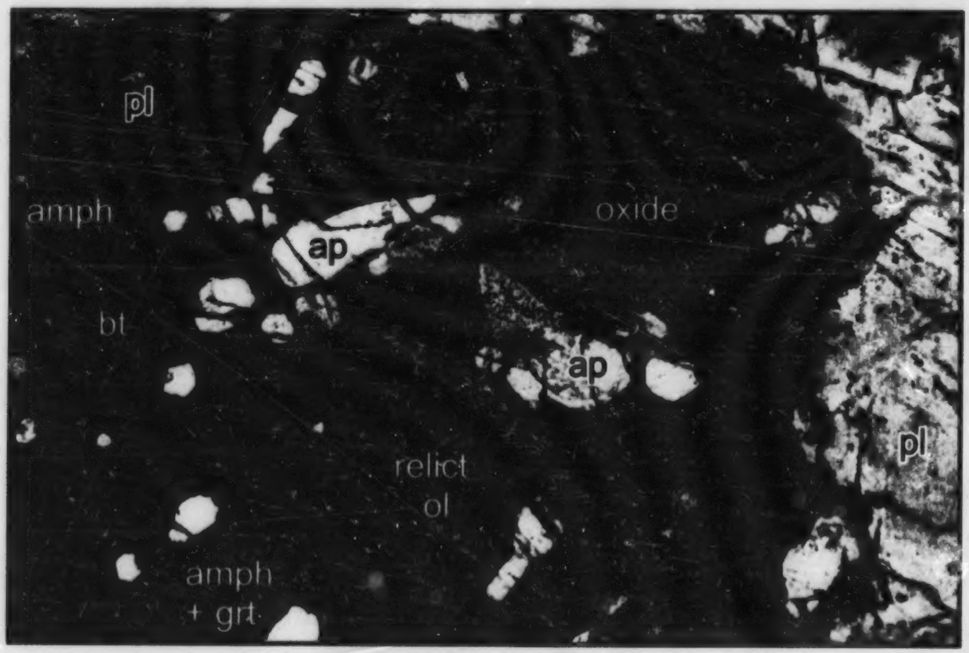

Photo 11. Photomicrograph of sample 01-RME-0142, troctolite from the Fanny Lake intrusion, showing metamorphic corona development around olivine grains, as well as large apatite grains typically of troctolite layers within the intrusion. Field of view roughly 3.8 mm wide. Abbreviations: amph = amphibole, ap = apatite; bt = biotite; grt = garnet, ol = olivine, pl = plagioclase.

Photo 12. Close-up of fine-scale cryptic layering in leucotroctolite (unit 9) of the Fanny Lake intrusion, southern McDiarmid Lake. Hammer handle is 30 cm long.

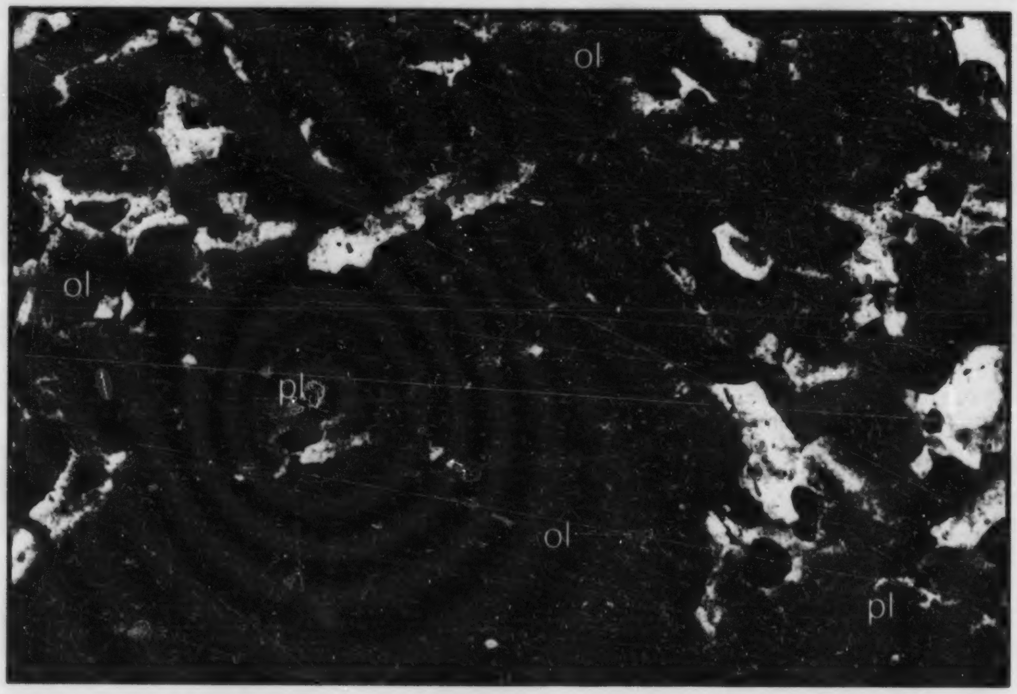

Photo 13. Photomicrograph of sample 01-RME-0307, troctolite to leucotroctolite from the Fanny Lake intrusion, showing presence of both large olivine grains (lower left corner) and dispersed, small olivine grains. Metamorphic corona development is poorly developed in this sample. Field of view roughly 3.8 mm wide. Abbreviations: ol = olivine, pl = plagioclase.

though they differ by roughly 300 m in relative stratigraphic position. Consequently, it is not possible to determine if there is any significant chemical fractionation within the intrusion that can be correlated with stratigraphic position without collecting considerably more data.

Although leucocratic, sample 01-RME-0191 contains olivine (Fo_{63-66}) and plagioclase (An_{67-88}) compositions similar to those observed in the melatroctolite units. Since this sample is from a dike, it indicates that a more primitive magma was injected into the already crystallized host troctolite. The dike composition could indicate either replenishment of the magma chamber during crystallization of the intrusion or injection of less fractionated magma from elsewhere in the intrusion.

Secondary corona mineralogy was not studied in detail, but is broadly similar in the 6 samples that were studied by microprobe. The coronas contain orthopyroxene with compositions of En_{65-70} (samples 01-RME-0180, 01-RME-0188, 01-RME-0190, *see* Appendix 2) in the troctolite and leucotroctolite , with the melatroctolite being slightly more magnesium rich with En_{69-72} (samples 01-RME-0191, 01-RME-0195, 01-RME-0199, *see* Appendix 2). Garnet in the coronas consists of pyrope ($Alm_{15-24}Prp_{46-60}Grs_{17-30}$) and almandine ($Alm_{41-55}Prp_{23-35}Grs_{8-27}Sps_{3-4}$). The crystallization order and significance of the 2 garnet compositions has not been determined.

Metamorphosed Mafic Intrusive Rocks (Unit 11)

Several varieties of metamorphosed mafic intrusive rocks are indicated on Map P.3452 (back pocket) and reflect either distinct textures within these rocks or broad compositional differences. All of these rocks were derived from units 7, 8 and 9, although very few examples of metamorphosed equivalents of the olivinites and plagioclase-poor melatroctolites (unit 7b) were observed. As described below, in thin section, rocks of unit 11 are much more homogeneous than they appear to be in outcrop. The rock types identified in the field and shown on Map P.3452 (back pocket) are as follows

- Unit 11a consisting of black- and white-weathering, medium-grained, hornblende gabbro to leucogabbro is likely derived from unit 9.
- Unit 11b consisting of black- and white-weathering, medium-grained, hornblende gabbro to gabbronorite is likely derived from unit 8.
- Unit 11c consisting of dark-weathering, medium-grained gabbro to gabbronorite is likely derived from more leucocratic varieties of unit 7.
- Unit 11d consisting of brown-weathering, serpentinized, medium- to coarse-grained, melatroctolite to olivinite is derived from unit 7.
- Unit 11e consisting of ophitic-textured hornblende gabbro to leucogabbro.
- Unit 11f consisting of fine-to medium-grained, clotty-textured, hornblende gabbro to leucogabbro.

In thin section, 2 main types of unit 11 appear to be present

1. The first type contains roughly equal amounts of amphibole and plagioclase as well as abundant, elongate apatite grains (*see* Photo 11). It would seem to correspond to rocks derived from olivine norites and troctolites of unit 8, which also contain abundant, similar-shaped, apatite grains.
2. The second type contains 30 to 40% amphibole, 45 to 60% plagioclase and 5 to 15% biotite (most likely derived from the breakdown of oxide minerals) and is most likely derived from leucotroctolite of unit 9.

Garnet may be present in both types of unit 11. Where present, garnet generally occurs as small grains which are associated with amphibole, possibly in what were once coronas that enveloped primary olivine grains. Amphibole in all thin sections of unit 11 is anhedral and occurs either as fine-grained aggregates or as inclusion-rich, partly resorbed, anhedral laths. Both green-brown and blue-green amphibole is present in both types of unit 11. Observations from progressively altered samples suggest that the fine-grained aggregates of amphibole represent the remnants of olivine grains, whereas the partly resorbed anhedral amphibole laths have replaced clinopyroxene. This preservation of primary texture, despite the thorough metamorphic recrystallization, is probably one reason why these rocks appear better preserved on weathered surfaces than they actually are in thin section.

Mafic Gneiss Derived from Units 7, 8 and 9 (Unit 12)

Rocks of this unit differ from the metamorphosed gabbros of unit 11 in that they possess a gneissic fabric. They are distinguished from mafic gneiss of unit 3 in that they can be clearly demonstrated in the field to be derived from rocks of unit 7, 8 or 9. Mafic gneiss of unit 12 occurs only in 2 areas 1) in the septum that separates the northwest body of the Fanny Lake intrusion from the main mass; and 2) as a carapace marginal to the southwest contact of the main mass of the Fanny Lake intrusion. Rocks of unit 12 are commonly strongly lineated as well as foliated, consisting mainly of black- and white-weathering amphibole and plagioclase, respectively and small, red garnet grains.

One sample of unit 12 from the southwest margin of the Fanny Lake intrusion was examined in thin section (01-RME-0166). It consists of 40 to 50% green brown and blue-green hornblende, 50 to 60% plagioclase and 10% biotite with minor apatite and opaque minerals. Mineralogically and texturally, it is indistinguishable from compositionally similar rocks of unit 3.

Fall Lake Intrusion

CONTACT RELATIONSHIPS

The intrusion consists of a main, teardrop-shaped mass located north of Fall Lake and a smaller, north-trending dike-like body southeast of the larger body (*see* Map P.3452, back pocket). The southwest part of the main mass (*see* Map P.3452, back pocket) shows the most lithologic variation, however, outcrop in this area is sparse and was insufficient to determine the relationships between these different phases (i.e., are they layers within the body or crosscutting phases, etc.?). The southwest lobe is dominated by gabbroic rocks of unit 11h that appear fresh on weathered surfaces, but in thin section, show partial or complete secondary replacement of clinopyroxene and olivine by fine-grained amphibole. The fine-grained character and radiating habit of the amphibole is similar to that found in other mafic rocks subjected to Grenville metamorphism, such as the River Valley intrusion, consequently, the amphibole is interpreted to have formed during amphibolite-facies regional metamorphism. In contrast, the northern part of the main mass, and the dike-like body, consist of leucocratic olivine gabbro to leucotroctolite (unit 13); in general, this phase is the best exposed portion of the intrusion. No stratigraphic sequence was identified within the Fall Lake intrusion.

Contacts of the Fall Lake intrusion are poorly exposed, particularly on the south and western flanks of the intrusion. The Fall Lake intrusion is similar to the Fanny Lake intrusion because seems to be a zone (50 to 400 m) of white- and black-weathering, recrystallized to foliated, metamorphosed gabbro along the south and west flanks of the intrusion. These rocks are most easily identified by their low magnetic susceptibility (~1) (*see* Appendix 3), in contrast to the higher magnetic susceptibility observed throughout the rest of the intrusion (~10 to 60) (*see* Appendix 3).

Along the northeast margin of the intrusion, 1 to 3 m of cover separates leucotroctolite from green-black-weathering mafic gneiss. The mafic gneiss contains 1 to 3 cm long plagioclase laths (*see* Photo 2), in a zone up to 50 m wide and over 100 m in length, that parallels the contact. The mafic gneiss unit in this area is thin and granite gneiss (unit 6) crops out within 200 m of the contact. The plagioclase laths are oriented parallel to the contact and occur in the olivine gabbro immediately adjacent to the contact. The presence of these laths is interpreted to be a result of a contact metamorphic effect of the intrusion.

ROCK TYPES

Metamorphosed Mafic Intrusive Rocks (Unit 11h)

As noted above, the southwest lobe is dominated by gabbroic rocks (unit 11g to 11i) that appear fresh on weathered surfaces, but show partial or complete replacement of clinopyroxene and olivine by secondary, fine-grained amphibole in thin sections. These rocks likely share the same metamorphic history of units 11a to 11f in the Fanny Lake intrusion. Three main rock types belonging to unit 11 were observed in the field, from most to least abundant, these are

1. a medium-grained gabbro (unit 11h);
2. a medium-grained olivine gabbro (unit 11i); and
3. a dark weathering, fine-grained gabbro metamorphosed to amphibolite (unit 11g).

These phases are variably weathered, particularly the olivine gabbros. In hand specimen, plagioclase exhibits occurs as stubby euhedral grains and lath-like grains.

Four samples were examined in thin section. The best preserved sample (01-RME-0067) is a medium-grained olivine gabbro that contains 55 to 60% dusty plagioclase, 10 to 15% olivine with thin coronas of greenish amphibole, 5 to 10% slightly reddish clinopyroxene, 5 to 10% biotite and oxide minerals with biotite rimming the oxide minerals, and 3 to 5% equant and elongate apatite.

Sample 01-RME-0066, which in hand sample seemed relatively well preserved, is medium grained and almost totally recrystallized. Sample 01-RME-0066 was collected only 50 m from sample 01-RME-0067, but both samples are very similar in chemical composition (*see* Appendix 1). Sample 01-RME-0066 consists of 30 to 50% plagioclase containing inclusion trains of small garnets, and 50% blue-green and green-brown amphibole generally radiating around older minerals retrograded to chlorite (10%). Oxide minerals make up 5% of the sample and are surrounded by fine-grained radiating aggregates of red brown biotite (5 to 15%). Elongate apatite grains are also present.

Sample 01-RME-0072 is medium grained and intermediate between samples 01-RME-0067 and 01-RME-0066 in its degree of recrystallization. Relict olivine (5%) is rimmed by laths of blue-green and green-brown amphibole and oxide minerals (5%) are rimmed by red-brown biotite laths (5%). Equant and elongate apatite grains are abundant (3 to 5%). Plagioclase constitutes roughly 55% of the sample.

Sample 01-RME-0075 is extremely fine grained and may represent a chilled phase or thick, crosscutting dike within the intrusion. It consists almost entirely of elongate, blue-green amphibole crystals with minor amounts of oxide minerals, biotite and titanite. Elongate and equant apatite constitutes 5 to 10% of the sample. The high apatite concentration is reflected in elevated P_2O_5 content (*see* Table 3).

Microprobe examination indicates that olivine is iron rich (*see* Appendix 2) with sample 01-RME-0067 (medium-grained olivine gabbro) containing olivine of composition Fo_{34-37} with less than 75 ppm Ni. Calcic plagioclase is of andesine composition (An_{44-49}) (*see* Appendix 2). Neither olivine or plagioclase shows any significant difference in core and rim compositions suggesting the absence of growth-related compositional zoning. The oxide mineral phase is mainly ilmenite.

Microprobe examination of the fine-grained gabbro (sample 01-RME-0075, *see* Appendix 2), metamorphosed to amphibolite, indicates that the dominant amphibole is ferroactinolite with a few grains of grünerite also present. The preliminary data seem to indicate that rocks related to the Fall Lake intrusion (samples 01-RME-0067, 01-RME-0075, *see* Appendix 2) contain ferroactinolite as the dominant amphibole, whereas country rocks (samples 01-RME-0127 and 01-RME-0128, *see* Appendix 2) contain ferrohornblende as the dominant amphibole. The main chemical differences between these 2 species is that ferrohornblende contains more aluminium and magnesium and less silica than ferroactinolite.

Leucotroctolite and Related Rocks (Unit 13)

The northern part of the main mass of the Fall Lake intrusion, and the dike-like body, consist of leucocratic olivine gabbro to leucotroctolite. This phase is the best exposed portion of the intrusion. Plagioclase occurs as stubby euhedral grains and lath-like grains in hand specimen. In thin section, this rock is fresh and shows little evidence of reaction rims around the mafic minerals, although biotite reaction rims are commonly present around oxide minerals. This lack of obvious metamorphic mineralogy or well-developed reaction rims is one reason why these rocks were shown as a separate unit on Map P.3452 (back pocket) rather than as a variety of unit 9.

Three samples were examined in thin section: 01-RME-0106, 01-RME-0113 and 01-RME-0121. Sample 01-RME-0121 was selected for microprobe examination and was the sample from the Fall Lake intrusion on which U/Pb geochronology was performed. Samples 01-RME-0106 and 01-RME-0121 are similar with both containing olivine (15%), a reddish-brown pyroxene (15%) that microprobe examination suggests is diopside, plagioclase (55%) with a Michel–Levy determined composition of labradorite (An_{50-52}), biotite (5%), oxide minerals (5%), and apatite (1 to 3%). Sample 01-RME-0106 shows the incipient development of a reaction rim of fine-grained greenish amphibole and spinel around olivine, but only where olivine is in contact with plagioclase. Diopside commonly rims olivine grains and was likely a primary phase that nucleated and partly resorbed the earlier formed olivine grains as the crystallizing magma became silica saturated. In both samples, red-brown biotite rims oxide minerals and likely represents a breakdown reaction related to regional metamorphism. Sample 01-RME-0113 contains significantly more olivine (30%) and less diopside (5%) than do the other 2 samples. In this sample, the biotite coronas around the oxide minerals are thicker than in the other 2 samples; thin rims of greenish amphibole and spinel are present around olivine; and some diopside grains show the development of blue-green amphibole rims. All 3 samples show similar CIPW normative compositions consisting of olivine (5 to 7%), plagioclase feldspar (66 to 70%), potassium feldspar (5 to 7%), apatite (1%), titaniferous minerals (3 to 5%) and oxide minerals (11 to 15%).

Microprobe examination of sample 01-RME-0121 indicates that olivine is iron rich (Fo_{38-44}) and contains less than 50 ppm Ni (*see* Appendix 2). Diopside, bordering on titanian diopside, has the composition $Wo_{47.2-49.8}En_{32.9-35.3}Fs_{17.0-17.2}$. Plagioclase is andesine with the composition An_{41-49}, although one matrix grain records a more sodic composition of An_{32}. Neither olivine or plagioclase showed any significant difference in core and rim composition, suggesting the absence of growth-related compositional zoning. Oxide mineral phases are ilmenite or titaniferous magnetite.

Geochemistry

Geochemical results are compiled in Appendix 1. Table 3 is a comparison chart showing representative samples from each intrusion, as well as samples from other rock suites. Both intrusions are slightly alkalic in composition, lying near or on the tholeiite–alkalic dividing line on most major element discrimination plots (Figure 5a; Table 4). A slightly alkalic character is consistent with the presence of fayalitic olivine and titanian diopside in both intrusions. On an AFM diagram, rocks of the Fanny Lake intrusion show a calc-alkalic rather than a tholeiitic differentiation trend (Figure 5b). This is also evident

Table 3. Representative chemical analyses from the Fanny Lake and Fall Lake intrusions. Average composition of Sudbury diabase dikes from the River Valley area (Easton and Hrominchuk 2002), a representative sample of the Tibbet Hill metavolcanic rocks (Pitson, Kumarapeli and Morency 1985), and the Ice Harbor flow of the Columbia River Basalt Group (CRBG)(Swanson and Wright 1980) are shown for comparison.

	Fall Lake Intrusion			Fanny Lake intrusion				CRBG	Average	Tibbet
Sample No.	**01-RME-0075**	**01-RME-0067**	**01-RME-0121**	**01-RME-0195**	**01-RME-0199**	**01-RME-0190**	**01-RME-0180**	**Ice Harbor Flow**	**Of 8 Sudbury dikes**	**Hill, sample 4**
Rock Type	**Fine-grained gabbro (unit 11g)**	**Olivine gabbro-norite (unit 11h)**	**Leuco-troctolite (unit 13)**	**Olivinite (unit 7b)**	**Mela-troctolite (unit 7a)**	**Troctolite (unit 8)**	**Leuco-troctolite (unit 9)**	**Basalt**	**Olivine gabbro**	**Meta-basalt**
Easting	613000	612630	614185	611777	611984	611572	610910			
Northing	5188327	5188300	5189650	5189362	5188956	5189022	5187010			
wt %										
SiO_2	36.86	41.05	46.38	35.79	40.61	47.64	47.34	47.50	44.59	46.85
TiO_2	4.96	5.67	2.85	0.55	0.63	1.21	1.15	3.79	2.93	3.06
Al_2O_3	8.11	15.23	20.62	2.76	11.43	20.90	20.26	12.50	16.07	15.32
Fe_2O_3	27.65	21.35	12.91	24.36	18.16	10.42	11.43	19.44	18.27	13.50
MnO	0.34	0.24	0.14	0.26	0.20	0.12	0.13		0.21	0.28
MgO	6.88	6.05	3.86	29.73	18.19	7.22	8.07	4.41	6.16	6.75
CaO	9.63	5.90	7.70	1.42	5.08	9.38	8.70	8.80	7.93	7.35
Na_2O	2.35	3.51	4.28	0.52	1.78	3.36	3.36	2.44	3.04	2.99
K_2O	0.66	1.05	0.95	0.10	0.31	0.65	.52	1.23	1.01	0.01
P_2O_5	2.04	0.35	0.30	0.12	0.12	0.27	.20	1.54	0.49	0.43
CO_2	0.09	0.08	0.14	0.11	0.10	0.05	0.08		0.11	
S	0.03	0.14	0.07	0.04	0.03	0.03	0.03		0.06	
LOI	0.15	<0.05	<0.05	3.81	3.38	<0.05	<0.05		0.06	4.13
Total	99.63	100.62	100.20	99.42	99.99	101.17	101.16		99.32	100.66
Mg #	33.01	35.95	37.19	70.73	66.48	57.85	58.30	31.00	39.40	49.75
ppm										
Cr	<4	5	6	122	78	55	69		61	
Ni	22	58	49	935	518	150	207		101	
Co	79	94	57	187	118	59	67		62	
Sc	52	17	9	9	9	10	9		21	
V	74	227	168	34	41	73	107		367	
Cu	<5	86	20	<5	<5	23	18		100	
Zn	243	186	117	163	130	79	89		171	
Rb	12	16	14	2	3	8	6		7	
Ba	512	858	768	98	222	436	385		557	
Sr	186	456	678	62	327	605	599		295	676
Nb	15.6	19.2	12.0	2.1	2.6	7.1	5.2		13.8	26.0
Zr	170	158	128	23	20	56	36		214	201
Y	55	21	18	4	6	14	10		37	34
Zr/Y	3.1	7.5	7.1	5.8	3.3	4	3.6		5.8	5.9
La	47.49	19.13	17.38	3.12	4.72	11.86	8.56		25.75	25.40
Ce	107.22	41.32	38.21	7.31	10.40	27.04	19.27		53.48	57.80
Pr	17.11	5.75	5.23	1.01	1.41	3.64	2.62		7.41	
Nd	77.01	23.46	21.26	4.43	6.21	15.61	11.20		32.76	31.50
Sm	16.57	4.78	4.33	0.98	1.33	3.39	2.33		7.14	7.21
Eu	4.00	2.22	2.32	0.33	0.73	1.39	1.20		2.15	2.39
Gd	15.94	4.53	4.03	0.96	1.27	3.20	2.14		6.79	
Tb	2.20	0.68	0.62	0.14	0.19	0.46	0.32		1.06	0.96
Dy	11.80	3.97	3.39	0.89	1.14	2.70	1.88		6.25	
Ho	2.28	0.82	0.70	0.18	0.23	0.54	0.39		1.28	
Er	5.70	2.23	1.89	0.51	0.69	1.46	1.10		3.40	
Tm	0.76	0.34	0.28	0.07	0.10	0.22	0.16		0.57	
Yb	4.29	2.11	1.70	0.48	0.62	1.45	0.93		3.30	2.93
Lu	0.68	0.33	0.27	0.08	0.09	0.20	0.16		0.50	0.45
ΣREE	313.1	111.6	101.6	20.5	29.1	73.3	52.3		151.9	>129

on a Jensen diagram (Figure 6a), where the Fall Lake and Fanny Lake intrusions show different fractionation trends. Rocks from both intrusions show the most affinities with within-plate basalts on major and trace element tectonic discrimination diagrams, as summarized in Table 4.

Within the Fall Lake intrusion, 2 chemical groupings are present, which are best distinguished using trace and rare earth elements (Figures 6b and 7a). One group, consisting of the more mafic phases, is characterized by gently sloping, chondrite-normalized rare earth element patterns with no Eu anomaly (*see* Figure 7a). The other group, consisting of leucocratic phases, also has a gently-sloping, chondrite-normalized rare earth element pattern, but with lower total rare earth content and positive Eu anomalies (*see* Figure 7a). The differences between the 2 groups can be attributed to plagioclase accumulation in the leucocratic phases.

As first noted in Easton (2001), there are some geochemical differences between the Fanny Lake and Fall Lake intrusions (*see* Figures 5a, 5b, 6a, 6b, 7a and 7b). For example, on a Sr–Ba–Zr ternary diagram (Figure 8), the Fall Lake rocks largely overlap the field of the Sudbury diabase dikes. On this plot, the lower Zr contents of the Fall Lake samples may simply be the result of plagioclase accumulation in most of the samples. In contrast, most of the Fanny Lake samples do not overlap the Sudbury diabase dike field and show a considerable spread in Ba and Sr content, likely the result of the wide range of olivine abundance (from approximately 90 to 30%) amongst the samples. Most notably though, rocks of similar composition in both intrusions, namely the leucotroctolites, show little overlap on the Sr–Ba–Zr diagram (*see* Figure 8) or in rare earth element contents (compare Figures 7a and 7b). Chemically, the troctolites and leucotroctolites of the Fanny Lake intrusion are similar in composition (*see* Table 3). The most fractionated rocks of the Fanny Lake intrusion, based on the content of incompatible elements, such as Ba, P_2O_5, TiO_2 and Zr, occur along the west side of the main body of the intrusion. In most instances, the fractionated rocks of the Fanny Lake intrusion have been recrystallized to metagabbro (unit 11).

Table 4 summarizes the inferred tectonic settings of the Fanny Lake and Fall Lake intrusions as determined from 14 trace element and 4 major element discrimination diagrams. The fact that these diagrams do not indicate a single tectonic setting, or that some samples plot outside the field boundaries on some of the diagrams, is, in part, a reflection that some of the samples from the Fanny Lake and Fall Lake intrusions do not represent original, chilled, parental magma compositions and include rocks that have likely undergone crystal fractionation within a magma chamber(s). Nonetheless, most of the discrimination diagrams suggest derivation from a plume-related or enriched-mantle source (within-plate basalt or enriched mid-ocean ridge basalt) and that the magma was likely weakly alkalic in composition.

The geochemical data suggest an affinity with some continental flood basalt sequences, for example, the slightly alkalic Picture Gorge basalts of the Columbia River Basalt Group or basaltic rocks of the Tibbet Hill volcanics, dated at about 570 Ma, located further south along the Ottawa graben system (Pitson, Kumarapeli and Morency 1985). If these intrusions are related to a flood basalt system, of whatever age, then it is unclear as to why only two small intrusions of what would have been an extensive magmatic system are apparently preserved. In addition, it is unclear as to why the intrusions are located where they are, as they do not appear to be at the confluence of any major regional structures.

Lange (2002) has attributed the high iron content (13.3 to 18.9 weight % total Fe_2O_3) of the Columbia River Basalt Group to the presence of a high volatile content (greater than 4 weight %) in the magmatic source region, a feature that would also explain the strong enrichment in incompatible elements (e.g., K, P, Ba). Lange's (2002) suggestion is also consistent with Faure's (2001) argument that the Columbia River Basalt Group formed by decompression melting in a continental back-arc basin setting, involving magma sources that included old subcontinental lithosphere and mantle rocks that had been altered by aqueous solutions emanating from subducted sediment of the Juan de Fuca plate. The geochemical similarities between the Columbia River basalts and the Fanny Lake and Fall Lake intrusions suggests that a continental back-arc tectonic setting is a viable alternative to the mantle plume origin generally attributed to the Sudbury dike swarm (Fahrig 1987; Ernst and Buchan 2001).

Table 4. Inferred tectonic settings for rocks from the Fanny Lake and Fall Lake intrusions, based on 18 trace and major element discrimination diagrams. Figure numbers refer to diagrams included in this report.

Plotted Elements (source in brackets)	Fanny Lake intrusion	Fall Lake intrusion
Trace Element Diagrams		
La–Ba (Gill 1981)	Low-K, medium-K, high-K tholeiite	High-K tholeiite
Th–La (Gill 1981)	Most samples plot in N-MORB field	Samples straddle boundary between N-MORB and E-MORB
Nb–La (Gill 1981)	Most samples plot in N-MORB field	Samples do not plot on diagram
Zr/4–Nb*2–Y (Meschede 1986) (*see* Figure 6b)	Within-plate tholeiite, P-MORB, volcanic arc basalt (B+C fields)	Within-plate alkalic basalt or within-plate tholeiite (AII field)
Zr–Ti (Pearce and Cann 1973)	Low-K tholeiite or ocean floor basalt (most in A field, some in B field, some outside of fields)	Do not plot or plot outside of fields
Zr–Ti/100–Y*3 (Pearce and Cann 1973)	Within-plate basalt or plot outside of fields	Within-plate basalt or plot outside of fields
Zr–Ti/100–Sr*2 (Pearce and Cann 1973)	Island-arc basalt or plot outside of fields	Island-arc basalt or plot outside of fields
Zr–Zr/Y (Pearce and Norry 1979)	Samples plot outside of fields	Within-plate basalt
Ti/1000–V (Shervais 1982)	Ocean-floor basalt, plot along "100" tie line	Ocean-floor basalt, samples plot in lower right quadrant
Nb/Y–Zr/TiO_2 (Winchester and Floyd 1977)	Subalkalic basalt	Alkalic basalt, near boundary with subalkalic basalts
Zr/TiO_2–SiO_2 (Winchester and Floyd 1977)	Subalkalic basalt	Subalkalic or alkalic basalts
Th–Zr/117–Nb/16 (Wood 1980)	E-MORB or within-plate tholeiite (B field) and destructive P-MORB (D field)	E-MORB or within-plate tholeiite (B field on diagram)
Th–Hf/3–Ta (Wood 1980)	Most samples are E-MORB or within-plate tholeiite (B field on diagram)	E-MORB or within-plate tholeiite (B field on diagram)
Th–Hf/3–Nb/16 (Wood 1980)	E-MORB or within-plate tholeiite (B field on diagram), some plot as alkalic within-plate basalt (C field)	E-MORB or within-plate tholeiite (B field on diagram)
Major Element Diagrams		
SiO_2–Alkali (Irvine and Baragar 1971) (*see* Figure 5a)	Samples plot in alkalic field	Samples plot in alkalic field
Alkali–FeO*–MgO (Irvine and Baragar 1971) (*see* Figure 5b)	Most samples plot in tholeiite field, a few leucotroctolites plot in calc-alkalic field	Samples plot in tholeiite field, however, this may simply reflect high Fe and Ti content of the samples
Al_2O_3–FeO*+TiO_2–MgO (Jensen 1976) (*see* Figure 6a)	Samples plot in komatiite, high-magnesium and high-iron tholeiite and calc-alkalic basalt fields	Samples plot in high-iron tholeiite field
MnO–TiO_2/10–P_2O_5 (Mullen 1983)	Samples plot in both ocean-island tholeiite and ocean-island andesite fields	Samples plot in both ocean-island tholeiite and ocean-island andesite fields

Abbreviations: E-MORB = enriched mid-ocean ridge basalt; N-MORB = normal mid-ocean ridge basalt; P-MORB = primitive mid-ocean ridge basalt.

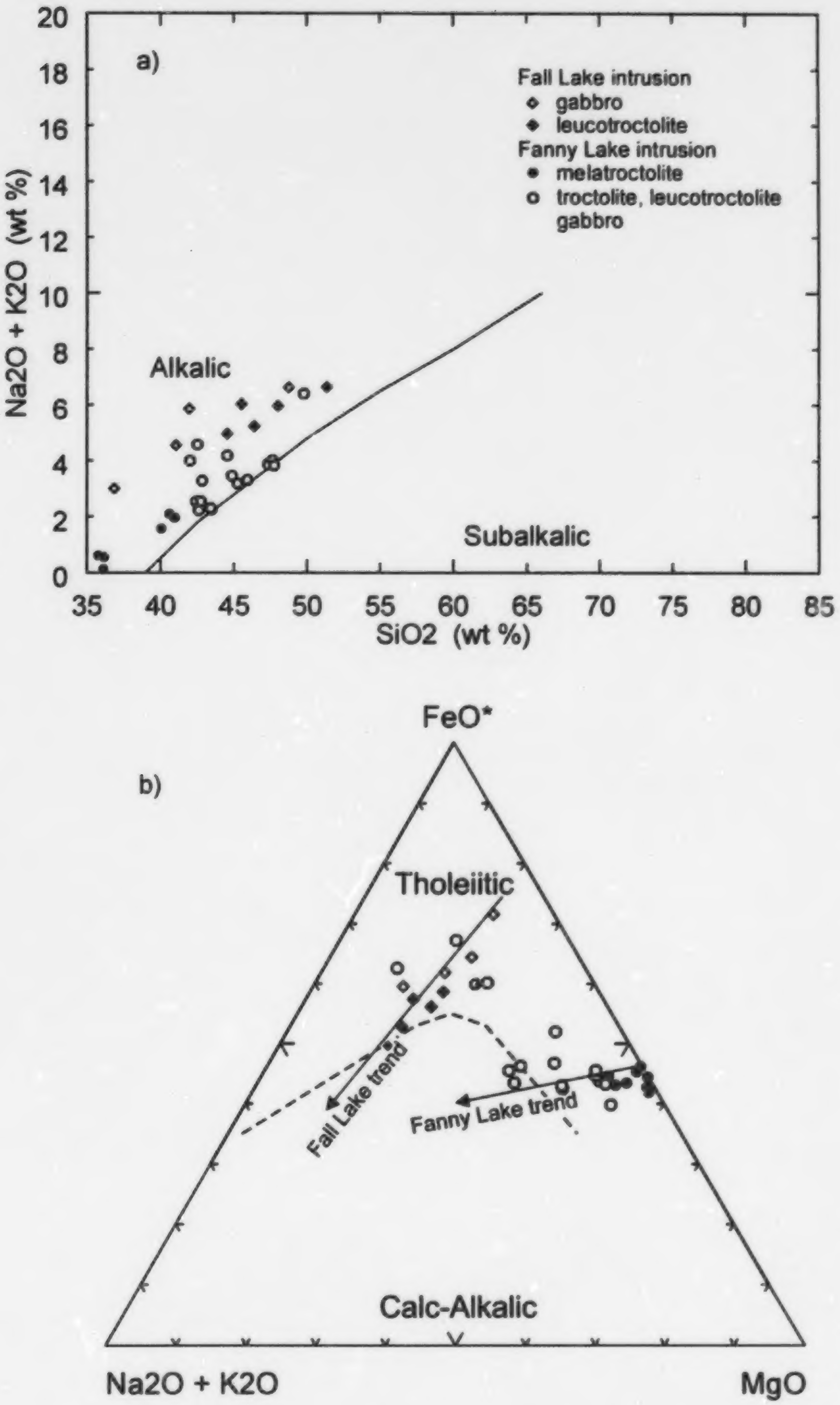

Figure 5. Geochemical features of the Fanny Lake and Fall Lake intrusions. **a)** Alkali-silica diagram of Irvine and Baragar (1971) illustrating that all samples from both intrusions lie in the alkalic field. **b)** AFM diagram of Irvine and Baragar (1971) illustrating the higher iron content of the Fall Lake intrusion samples. Note that the samples from both intrusions lie along different apparent fractionation trends. All data are listed in Appendix 1. The same sample symbols are used in Figures 5a, 5b, 6a and 6b.

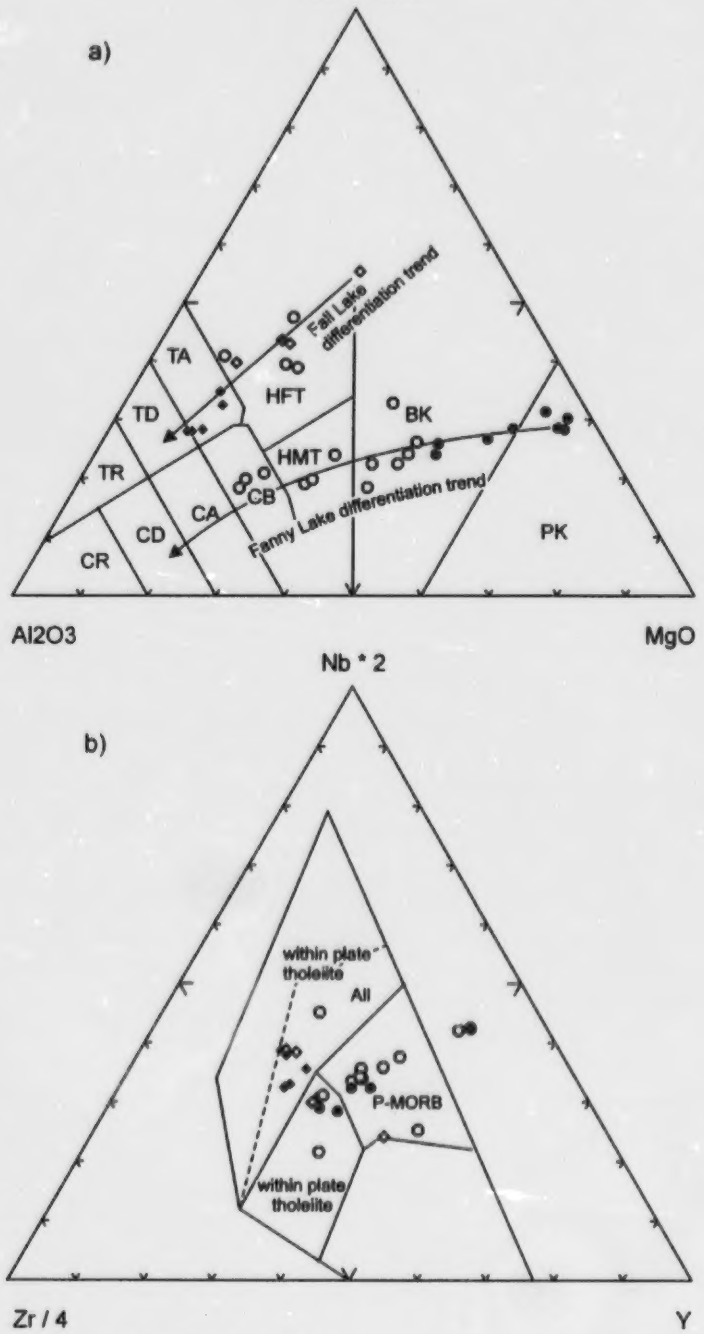

Figure 6. Geochemical features of the Fanny Lake and Fall Lake intrusions. **a)** Jensen diagram. Note that the samples from both intrusions lie along different apparent fractionation trends. **b)** Zr/4–Nb*2–Y plot (*after* Meschede 1986) for samples of the Fanny Lake and Fall Lake intrusions. Abbreviations: N-MORB = normal mid-ocean ridge basalt, P-MORB = primitive mid-ocean ridge basalt. All data are listed in Appendix 1. The same sample symbols are depicted in Figures 5a, 5b, 6a and 6b.

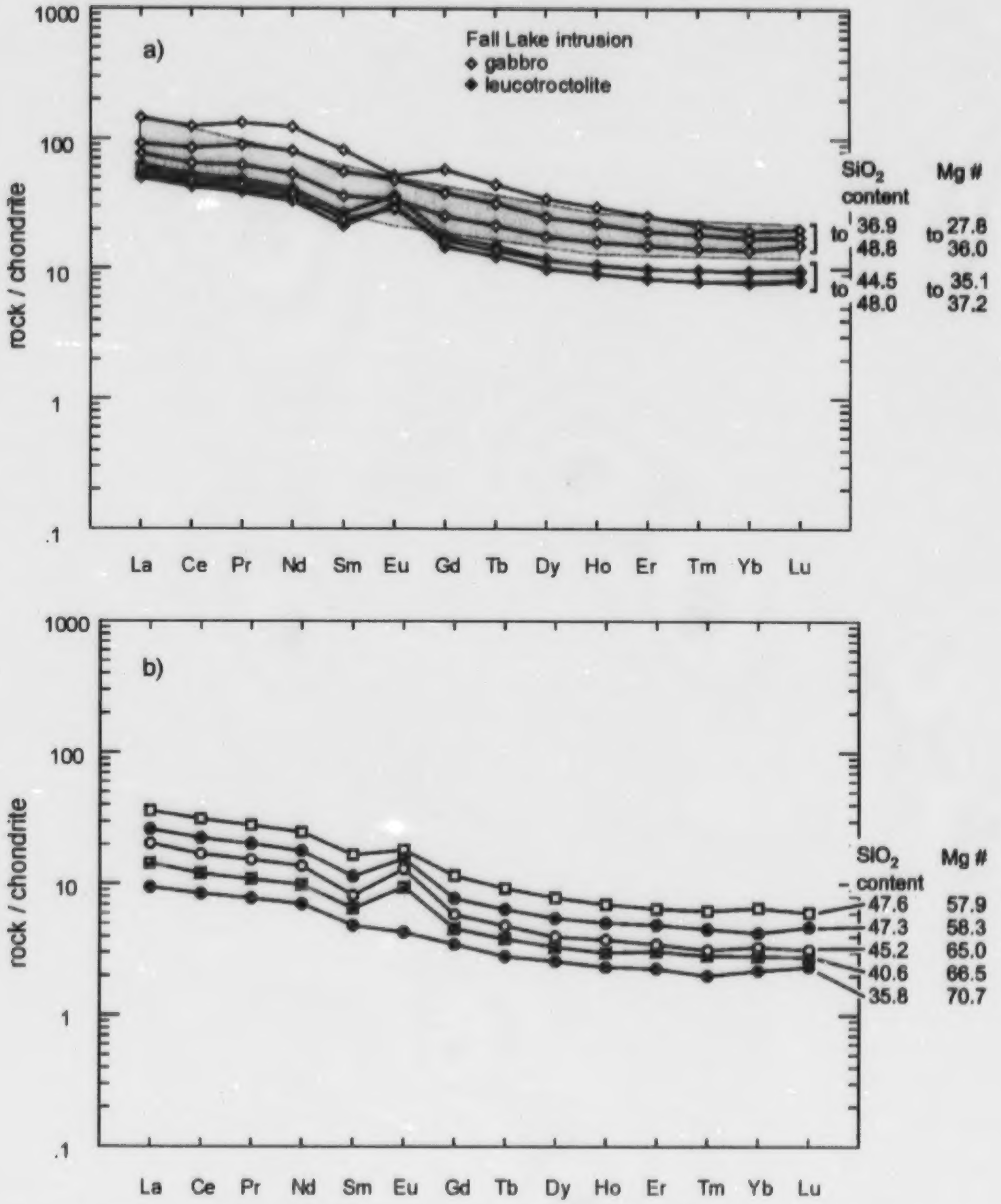

Figure 7. Geochemical features of the Fanny Lake and Fall Lake intrusions. **a)** Chondrite-normalized rare earth element patterns for samples from the Fall Lake intrusion, grouped by metagabbro phases (unit 11) and leucotroctolite phases (unit 13). Lower total rare earth element contents and positive Eu anomaly in leucotroctolite samples can be attributed to accumulation of plagioclase in these samples. Grey shading indicates field of 8 Sudbury diabase dike samples from the River Valley area (Easton and Hrominchuk 2002). **b)** Chondrite-normalized rare earth element diagram for representative samples from the Fanny Lake intrusion. Note trend from low total rare earth element content and no Eu anomaly in more mafic samples (low silica and high Mg numbers) to increased total rare earth element content and positive Eu samples in the more leucocratic samples (higher silica and lower Mg numbers). In comparing Figure 7a and 7b, note overall lower total rare earth element contents in the Fanny Lake samples.

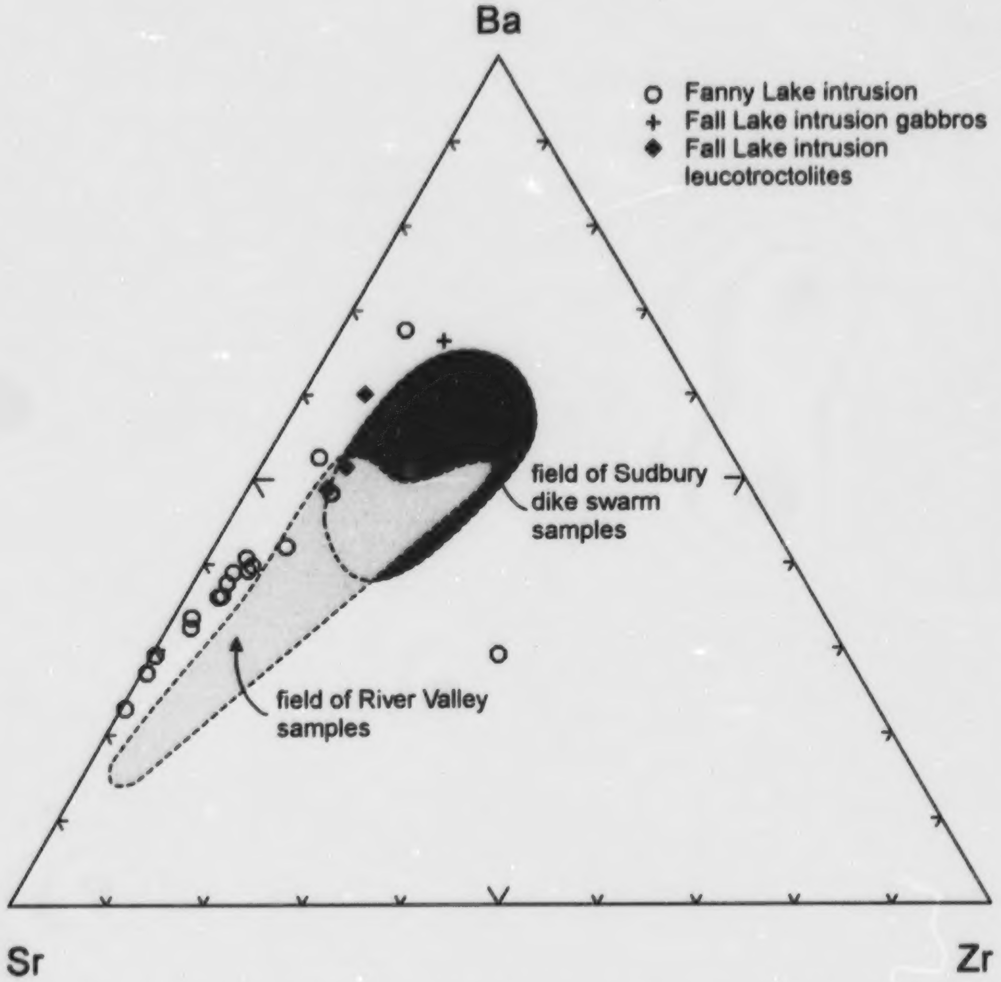

Figure 8. Geochemical features of the Fanny Lake and Fall Lake intrusions. Sr–Ba–Zr diagram (*after* Ketchum and Davidson 2000). Note overlap between most Fall Lake intrusion samples and the Sudbury dike swarm samples. Note linear trend defined by Fanny Lake intrusion samples, but lower zirconium contents. Field of River Valley samples is from data contained in Easton and Hrominchuk (2002). Field of Sudbury dike swarm samples is from Ketchum and Davidson (2000), but augmented by data contained in Easton and Hrominchuk (2002).

CENOZOIC

Quaternary

PLEISTOCENE AND RECENT

Approximately 20 000 years ago, the study area was covered by the Laurentide ice sheet (Barnett 1991). On the basis of glacial striae orientations in the Timiskaming area, it has been proposed that 3 different stages of ice flow direction affected the region. The oldest, a west-southwest flow (230 to 270°) and a younger south-southwest flow (180 to 220°) were overprinted by the latest south-southeast ice flow (130 to 170°) (Veillette 1986).

Deglaciation of the study area, approximately 9500 to 11 000 years ago, resulted in the formation of large glacial lakes at the receding glacier margin. The last of these glacial lakes were drained approximately 5500 years ago, however, none of the Quaternary deposits in the study area can be attributed to glacial lake deposition. Few glaciolacustrine (sand to gravel-rich) sediments are present. Swamp and organic deposits are common in low-lying areas, particularly along major drainage systems. In many cases, these low-lying areas correspond to fault zones.

High-density lake sediment geochemistry was conducted in the Temagami area, including the study area, during the 2001 field season as part of an Operation Treasure Hunt project (Dyer and Roy 2001). In addition, a modern alluvium sampling study was conducted in the Temagami area and study area during the 2001 field season (Reid 2001), focussing on kimberlite indicator minerals. Results of both surveys were unavailable at the time of report preparation.

Metamorphism

Regional metamorphic grade is inferred to have occurred under estimated conditions of between 640 to 670°C and between 4.5 to approximately 7 kilobars, based on a detailed version of the petrogenetic grid presented by Berman, Easton and Nadeau (2000). These conditions correspond to middle amphibolite facies. The upper temperature limit is constrained by the fact that the host rocks and the rocks in the intrusion contain little or no melt (leucosome or mesosome); contain no metamorphic orthopyroxene; and quartzose schists of unit 5 contain muscovite and no aluminosilicate phase suggesting that the latter never reached conditions of muscovite breakdown. The lower temperature limit is constrained by the lack of epidote in the mafic rocks, and the oligioclase to andesine composition of the feldspars in the host rocks. The lower pressure limit is inferred by the presence of almandine garnet and grünerite in the mafic rocks. The upper pressure limit is more poorly constrained, although the presence of titanite and ilmenite, rather than rutile, indicates these rocks were affected by low to intermediate pressures.

Within the mafic intrusive rocks (units 7 to 13), there is a progressive grain size increase coincident with the change from igneous to metamorphic mineralogy and texture. This change in grain size is most apparent in secondary biotite and amphibole. Grain size is small (<100 mm) where biotite and amphibole first form as rims around oxide minerals or olivine. The biotite and amphibole grains are generally elongate and oriented perpendicular to the grain boundary of the original primary mineral. First biotite, then amphibole, develop into larger, lath-like forms (5 to 15 mm) with progressive recrystallization and increasing destruction of the primary mineral grains. Early formed biotite and amphibole are inclusion rich and consist of aggregates of many small grains, particularly the amphibole. With increasing metamorphic recrystallization, the amphibole becomes more euhedral in form, larger in size (15 to 30 mm) and contains fewer inclusions. Early formed amphiboles exhibit mainly blue-green pleochroism, however, green and green-brown pleochroism is more common with increasing grain size.

As noted previously (*see also* Appendix 2), there is little difference in chemistry between the blue-green and green and green-brown amphibole. The common presence of both pleochroic amphibole types in most samples is simply a reflection of the different degree of recrystallization that has occurred (i.e., blue-green amphiboles are early and green and green-brown amphiboles are late).

Plagioclase is slower to recrystallize and only forms smaller, more equant grains (15 to 30 mm), after the primary mafic minerals in the samples have completely broken down. This change in grain size indicates that secondary coronas developed during regional metamorphism.

Geophysics

AEROMAGNETIC DATA AND REGIONAL GRAVITY DATA

Aeromagnetic geophysical anomalies and regional Bouguer gravity highs (Ontario Geological Survey 1991a, 1991b, 1991c; Terraquest 1999; *see also* geophysical images on Map P.3452, back pocket) are associated with the Fanny Lake intrusion. The aeromagnetic geophysical data show the presence of a northwest lobe of the intrusion separated from the main body by a magnetic low. The southwestern margin of the northwest lobe, delineated by bedrock mapping, extends several hundred metres south of the aeromagnetic anomaly. For the eastern half of the Fanny Lake intrusion, contacts delineated by bedrock mapping and contacts interpreted between aeromagnetic and regional Bouguer gravity anomalies correspond fairly closely with interpreted intrusive contacts. In contrast, in the west, the contacts between aeromagnetic and regional Bouguer gravity anomalies extend several hundred metres further west than the western geological contact delineated by bedrock mapping. The aeromagnetic data also indicate the presence of a north-trending magnetic fabric in the main body of the intrusion that appears to correspond with the trend of igneous layering (Terraquest 1999).

There is less correspondence between the surface geological contacts of the Fall Lake intrusion and aeromagnetic and Bouguer gravity anomalies (Ontario Geological Survey 1991a, 1991b, 1991c; *see also* Map P.3452, back pocket). An aeromagnetic high is generally coincident with distribution of the leucocratic olivine gabbro phase of the intrusion, with the centre of the anomaly centred near the O'Connor magnetite occurrence, however, the anomaly extends for an additional 1 km west of the intrusion. The Fall Lake intrusion lies within the broad Bouguer gravity anomaly associated with the Fanny Lake intrusion.

MAGNETIC SUSCEPTIBILITY DATA

Magnetic susceptibility measurements collected during this study are presented in Appendix 3 and summarized in Table 5. Measurements were collected using an Explorium® KT-9 magnetic susceptibility meter. Magnetic susceptibility is defined as the degree to which a substance can be magnetized and, in this case, is expressed as the ratio of the intensity of magnetization (k) to the ratio of the Earth's magnetic field to magnetic field induced by the susceptibility meter. The readings (k) are expressed as 10^{-3} times the SI unit for susceptibility and are dimensionless. The minimum value that can be recorded by the meter is 0.01 times 10^{-3} SI units; the largest value is 999 times 10^{-3} SI units.

Table 5. Summary of magnetic susceptibility characteristics of map units from the study area. Condensed *from* Appendix 3.

Map Unit	**Magnetic Susceptibility (typical values per outcrop)**	**Interpretation**
Mafic gneiss (unit 3)	0.8 to 1.1	Magnetic minerals destroyed during metamorphism
Biotite-hornblende diorite gneiss (unit 4)	0.4 to 0.7	Magnetic minerals destroyed during metamorphism
Gneissic granite (unit 6)	0.00 to 0.2, 0.5 to 0.7, 1.2 to 7	Magnetic minerals only partly destroyed during metamorphism
Metagabbro (at margin of Fall Lake intrusion)	0.6 to 1.2	Magnetic minerals destroyed during metamorphism
Metagabbro (unit 11h, Fall Lake intrusion)	25 to 70	Magnetic minerals mainly intact
Leucotroctolite (unit 13, Fall Lake intrusion)	17 to 70, over 90 marginal to O'Connor magnetite occurrence	Magnetic minerals mainly intact
Leucotroctolite (unit 9, Fanny Lake intrusion)	4 to 12, average 8	Magnetic minerals mainly intact
Troctolite (unit 8, Fanny Lake intrusion)	7 to 25, average 10 to 12	Magnetic minerals mainly intact
Melatroctolite (unit 7, Fanny Lake intrusion)	15 to 75 in rock, alteration veins 90 to 575	Alteration veins contain new magnetite grains, which is responsible for the high readings from the veins

Strongly recrystallized or gneissic mafic units, including mafic gneiss of unit 3, and the most strongly recrystallized varieties of unit 11 (gabbro) all show relatively low and consistent measurements on the order of 0.8 to 1.2. Biotite-hornblende diorite gneiss of unit 4 also possesses relatively low, consistent values of between 0.4 and 0.7. The homogeneity of these rock types and their low magnetic character probably reflects destruction of most primary magnetic minerals in these rocks during regional metamorphism.

Granite gneiss (unit 6) shows a considerable range of measurements that could not be directly linked to any particular feature in the rock, such as compositional layering or the presence of inclusions. Generally, these rocks are nonmagnetic in character (<0.2), but regularly show scattered measurements of 1.2 to 6.9. One explanation for this variation is that these rocks once had a more uniformly higher magnetic character and that the scattered measurements relate to varied degrees of metamorphic recrystallization in these rocks. Completely recrystallized rocks typically give low measurements and partly recrystallized rocks give higher measurements. Regional aeromagnetic anomalies that correspond to areas underlain by rocks of unit 6 may, in fact, be related to this varied degree of recrystallization of magnetic mineral phases.

Mafic rocks of the Fall Lake intrusion (units 11h and 13) show high measurements generally ranging from 20 to 60 on individual outcrops. The broad range observed in individual outcrops probably reflects the random distribution of magnetic minerals throughout the rock. The highest measurements of 112 and 125 were obtained from an outcrop 30 m south of the O'Connor magnetite occurrence. Measurements were attempted at the O'Connor magnetite occurrence, but the magnetite content in this rock exceeded the upper operational range of the susceptibility meter (over 1000 times 10^{-3} SI units).

The various units of the Fanny Lake intrusion show decreasing magnetic susceptibility with increasing plagioclase content (*see* Table 5) with melatroctolite of unit 7 containing the highest susceptibility and leucotroctolite of unit 9 with the lowest susceptibility. The highest measurements (up to 575) occur in magnetite-bearing alteration veins in rocks of unit 7. The contrast in magnetic susceptibility between units 7, 8 and 9 is probably one reason why detailed magnetic surveys of the Fanny Lake intrusion (e.g., Terraquest 1999) apparently reflect the north-trending stratigraphy in the intrusion.

It is also noteworthy that leucotroctolite of the Fall Lake intrusion contains much higher magnetic susceptibilities than those present in the Fanny Lake intrusion (17 to 70 versus 4 to 12) that may be linked to the origin of the O'Connor magnetite occurrence.

Discussion and Synthesis

The Fanny Lake and Fall Lake intrusions are not identical in chemical composition as outlined in the section on "Geochemistry"; in Table 4; and as illustrated in Figures 5, 6, 7 and 8. The chemical differences between the intrusions are mainly the result of higher iron and incompatible elements (Ba, Nb, P, REE, Ti, Zr) within the Fall Lake intrusion. It is unlikely that a simple process of fractionation of a magma chamber represented by a body the size of the Fanny Lake intrusion could generate the scale and homogeneity of enrichment in the incompatible elements in the Fall Lake intrusion. Geometrically, it is also difficult to explain the location of the fractionated rocks to the east, rather than the west, of the Fanny Lake body because field and chemical data suggest that the roof of the Fanny Lake intrusion faces west. Consequently, if the 2 intrusions are linked by a fractionation process, then it is likely through a much larger magma chamber that was present deeper in the crust. The differences between the intrusions could also be explained by invoking 2 different and separate batches of mantle-derived magmas. The later explanation would also be consistent with the field, petrographic, and geochronologic observations suggesting that the Fall Lake intrusion may be slightly younger in relative age.

The intrusions are not obviously related to any major regional fault systems (*see* Figures 1 and 2), although most of these regional faults are post-Grenville in age. The bodies could have been emplaced along 1 or possibly 2 now annealed fault systems. As noted previously, the mafic gneiss belt at Fall Lake apparently separates 2 distinct crustal blocks, now evident only as preserved relicts within the gneissic granites of unit 6. This zone could have localized emplacement of the Fall Lake intrusion, as well as the Fanny Lake intrusion, during Geon 12. The Fanny Lake intrusion may also have been emplaced along an old fault system that was present between the Red Cedar Lake gneiss and gneissic granites of the Tomiko domain. This early fault may have been subsequently reactivated to form the Tomiko domain – Grenville Front tectonic zone boundary.

Although there had been some previously unpublished speculation that the mafic intrusions in Flett Township might be correlative with the Paleoproterozoic East Bull Lake intrusive suite (James et al. 2002), which has high platinum group element mineral potential, the geochronological and geochemical evidence presented in this report suggests that this is not the case. Rather, the Flett Township mafic intrusions are most closely related to the Mesoproterozoic Sudbury diabase dike swarm. Table 6 summarizes the key features of the Flett Township mafic intrusions in comparison to the Sudbury diabase dike swarm and the East Bull Lake intrusive suite.

Fahrig (1987) and Ernst and Buchan (2001) both relate the Sudbury diabase dike swarm to the presence of a large mantle-plume, possibly with an associated spreading centre, located southeast of Sudbury (*see* Figure 1). A difficulty with this model is the absence of any evidence within the Grenville Province for the presence of such a spreading centre during Geon 12 (e.g., younger sedimentary sequences, unusual fault patterns, deep crustal intrusions, etc.) even taking into account the effects of Grenville metamorphism and deformation. If such rocks were present, they would have to be buried beneath allochthonous rocks present within the Central Gneiss Belt. In addition, it is difficult to resolve a model involving continental rifting and formation of even a small ocean basin with the evidence for compressional tectonics within the Central Gneiss Belt of the Grenville orogen in late Geon 12 and early Geon 11 time.

Table 6. Chart comparing the key features of the Fanny Lake and Fall Lake intrusions with the River Valley intrusion (East Bull Lake intrusive suite) and rocks of the Sudbury diabase dike swarm. Sources: this study; James et al. (2002).

Chemical Affinity	Rock Types	Primary Textures	Metamorphic Textures and Facies	Deformation	Mineralization and Au+Pd+Pt Background	Olivine and Plagioclase Composition
Fanny Lake intrusion (1238±2 Ma)						
Within-plate and low-K tholeiite, slightly alkalic, Mg# 71–58 (least altered samples)	Melatroctolite, troctolite, leucotroctolite. Stratigraphy present, but sequence not yet established.	Igneous layering and textures preserved.	Coronas around olivine throughout. In margins of body mafic minerals replaced by amphibole + garnet and development of mafic gneiss. Upper amphibolite facies.	Around edges of intrusion	Magnetite in veins in melatroctolite <8 ppb	Fo_{58-70} (cores only) An_{50-69}
Fall Lake intrusion (1235±2 Ma)						
Within-plate tholeiite, slightly alkalic, Mg# 28–37	Gabbro, olivine gabbro, leucocratic olivine gabbro.	Igneous textures preserved.	In southwest lobe, mafic minerals replaced by amphibole; middle amphibolite facies.	Minimal in intrusion.	Fe-T-V magnetite deposit. Ilmenite is main oxide. <8 ppb	Fo_{34-44} An_{44-49}
Sudbury diabase dike swarm (1238±4 Ma)						
Within plate tholeiite, alkalic, high Ba Mg# 45–35	Olivine gabbro.	Chill margins, igneous textures preserved.	Coronas around olivine and pyroxene, garnet develops in chill margins. Upper amphibolite facies.	Increases with increasing distance from Grenville Front.	No mineralization reported. <8 ppb	Fo_{26-33} An_{60}
River Valley intrusion (2475±2 Ma)						
High-alumina tholeiitic basalt, Mg# 78–43, average 60–65	Gabbronorite, norite, olivine norite, minor noritic anorthosite, stratigraphy from base to top is: marginal zone, inclusion-bearing zone, olivine gabbronorite zone, gabbronorite zone, leucogabbronorite zone	Igneous layering and textures preserved.	Coronas around olivine and orthopyroxene. Mafic minerals replaced by amphibole + garnet. Development of mafic gneiss. Upper amphibolite facies.	Throughout intrusion, better preserved parts are topographic highs. Less preservation with increasing distance from Grenville Front.	PGE+Cu sulphides in inclusion-bearing rocks near margin of intrusion. Magnetite is main oxide. 35–40 ppb	Fo_{64} Fo_{72-76} An_{68-73} An_{62-78} An_{58-75} An_{58-63}

As mentioned in "Geochemistry", an alternative tectonic setting for the Sudbury dike swarm and the Flett Township mafic intrusions is an extensional rift (i.e., back-arc) basin in a continental arc setting, similar to that in which the Columbia River Basalt Group was emplaced. Such an environment is more consistent with the inferred tectonic development of the southern Central Gneiss Belt, which envisages the presence of a continental arc regime between 1480 and 1300 Ma (e.g., Carr et al. 2000). It is also consistent with the timing of mafic and felsic magmatism in the North Bay region (*see* Figure 1; *see* Table 1) between 1270 to 1225 Ma, which occurs subsequent to shut-down of the major period of arc magmatism. The apparent concentration of magmatism of Geon 12 age in the Tomiko domain (*see* Figure 1) may indicate that the centre of this magmatic activity was centred somewhere in the vicinity of Mattawa. It is also likely that rocks of Geon 12 age may be more common in the northeastern Central Gneiss Belt in Ontario and western Quebec than has been previously recognized.

It is also possible to invoke a model involving a combination of back-arc spreading and an upwelling mantle plume for the Geon 12 magmatic activity in the Tomiko domain. Such a model would result in the generation of mafic and felsic magmas in the lower crust, but would not necessarily lead to development of a spreading centre or a failed continental rift. Opplinger, Murphy and Brimhall (1997) have suggested such a model for the Columbia River Basalt Group. This model also relates the development of Carlin-type gold deposits in the region to the period of back-arc extension that occurs prior to the main period of plume associated flood basalt volcanism. If this model is in any way applicable to the Tomiko domain, then alteration zones associated with large fracture systems located near Geon 12 granitic plutons such as the Mulock granite batholith would be the favoured target in any gold exploration program. Given the proximity of the Geon 12 mafic magmatism to the Grenville Front, gold might also be expected along large fracture systems cutting Archean and Paleoproterozoic rocks in the adjacent Temagami greenstone belt and Cobalt plate.

Economic Geology

ASSAY DATA

Assay data from 53 samples collected from both intrusions and surrounding country rocks are summarized in Table 7. No significant copper, nickel, platinum group element, gold or chromium mineralization was detected in any of the major units from either intrusion. Chromium and nickel values are higher in olivine-rich samples (olivine gabbro), but not exceptionally so. Previous exploration work on the Fanny Lake intrusion, that focussed on platinum group element mineralization, also reported low values for chromium, copper, nickel, platinum and palladium (Racicot and Keevil 1998). A sample of the O'Connor magnetite occurrence was assayed and gave results similar to those reported by Hurst (1932) (*see* Table 8).

DESCRIPTION OF PROPERTIES

O'Connor Occurrence

The O'Connor occurrence, also known as the Titan occurrence, is located near the northeast margin of the Fall Lake intrusion in Angus Township. This occurrence has not been actively explored for more than 40 years. The occurrence is coincident with the centre of a regional aeromagnetic high (the shape of which does not correspond to the mapped bedrock geology of the Fall Lake intrusion). The possibility exists that the magnetic mineralization is more extensive than is known from current surface exposures.

Hurst (1932) described the geology of the property, which consists of 2 belts of magnetite-bearing rocks: 1) a northwest-striking "A-zone" exposed at the shore of a small pond; and 2) a north-striking "B-zone" located about 100 m to the west of "A-zone". The more extensive "B-zone" had an estimated length of 100 to 150 m (Hurst 1932). Outcrop and samples from the "B-zone" were located and examined during this study, but the "A-zone" outcrops were now either covered by vegetation or were not accessible due to water levels. The 2 samples reported in Table 8 are from the "B-zone". Sample 01-RME-0125 was collected from the outcrop shown in the photograph in Hurst (1932, p.109), which is the likely site of the Hurst (1932) sample.

Hurst (1932) noted that the mineralized zones consisted of a mixture of titaniferous magnetite and altered gabbro, and, although streaks, patches and veinlets of solid magnetite were present, the magnetite and the gangue (altered gabbro) were intermingled. Hurst (1932) described the gangue assemblage as consisting mainly of pale-green talc, actinolite, and green spinel; locally, garnet and hornblende are present.

Table 7. Assay data for rocks from Flett and Angus townships. Detection limit for each element is listed in brackets under that element. Eastings and northings are in UTM zone 17T, NAD 83.

Sample No.	Easting	Northing	Field Rock Name	Au (5 ppb)	Co (5 ppm)	Cr (4 ppm)	Cu (5 ppm)	Ni (5 ppm)	V (5 ppm)	Pd (8 ppb)	Pt (8 ppb)
Fanny Lake intrusion											
01-RME-0140	610556	5187061	Rx gabbro	ND	30	ND	ND	14	ND	ND	ND
01-RME-0142	610554	5186635	Rx melagabbro	ND	82	ND	ND	18	341	ND	ND
01-RME-142-2	610586	5186640	Rusty boulder	ND	43	ND	ND	17	321	ND	ND
01-RME-0143	610600	5186298	Leucotroctolite	ND	83	44	31	263	44	ND	ND
01-RME-0144	610715	5186004	Gneissic gabbro	ND	50	30	18	159	57	ND	ND
01-RME-0166	610300	5186130	Gneissic gabbro	ND	ND	25	74	41	200	ND	ND
01-RME-0180	610910	5187010	Leucotroctolite	ND	67	69	18	207	107	ND	ND
01-RME-0188	611591	5188610	Leucotroctolite	ND	77	56	11	306	47	ND	ND
01-RME-0190	611572	5189022	Olivine gabbro	ND	59	55	23	150	73	ND	ND
01-RME-0191	611630	5189340	Leucotroctolite	ND	96	66	ND	403	ND	ND	ND
01-RME-0195	611777	5189362	Olivine gabbro	ND	187	122	ND	935	34	ND	ND
01-RME-0199	611984	5188956	Olivine gabbro	ND	188	78	ND	518	41	ND	ND
01-RME-0216	611230	5186510	Olivine gabbro	ND	139	84	ND	680	34	ND	ND
01-RME-0217	611089	5186188	Olivine gabbro	ND	183	131	7	840	46	ND	ND
01-RME-0225	611227	5187403	Olivine gabbro	ND	134	100	9	568	22	ND	ND
01-RME-0230	611062	5186836	Leucotroctolite	ND	120	403	12	380	57	ND	ND
01-RME-0251	611719	5188950	Olivine gabbro	ND	128	82	ND	659	10	ND	ND
01-RME-0256	611190	5188996	Olivine gabbro	ND	81	21	111	37	321	ND	ND
01-RME-0267	611580	5189850	Olivine gabbro	ND	101	475	ND	335	27	ND	ND
01-RME-0268	611607	5189654	Olivine gabbro	ND	104	623	ND	329	43	ND	ND
01-RME-0281	610875	5190668	Olivine gabbro	ND	132	77	ND	583	8	ND	ND
01-RME-0284	611488	5187777	Olivine gabbro	ND	186	111	ND	912	20	ND	ND
01-RME-0292	612276	5190319	Olivine gabbro	ND	103	74	ND	281	126	ND	ND
01-RME-0307	611330	5190653	Leucotroctolite	ND	83	56	11	288	40	ND	ND
01-RME-0313	611550	5188614	Leucotroctolite	ND	64	73	1125	186	97	ND	ND
01-RME-0314	611550	5188614	Leucotroctolite	ND	123	86	25	456	59	ND	ND
Fall Lake intrusion											
01-RME-0066	612678	5188162	Gabbro	ND	77	ND	96	33	118	ND	ND
01-RME-0067	612630	5188300	Ol leucogabbro	ND	94	5	86	58	227	ND	ND
01-RME-0068	612762	5188221	Gabbro	ND	42	ND	21	14	40	ND	ND
01-RME-0070	612931	5188000	Gabbro	ND	46	ND	20	13	19	ND	ND
01-RME-0071	612900	5188063	Gabbro	ND	48	ND	24	13	16	ND	ND
01-RME-0072	612880	5188087	Gabbro	ND	39	ND	6	14	19	ND	ND
01-RME-0075	613000	5188327	Fgr amphibolite	ND	79	ND	ND	22	74	ND	ND
01-RME-0076	613052	5188708	Gabbro	ND	64	7	30	18	176	ND	ND
01-RME-0078	612891	5188980	Gabbro	ND	54	ND	37	20	94	ND	ND
01-RME-0079	612950	5189213	Gabbro	ND	48	ND	32	19	88	ND	ND
01-RME-0081	612682	5188689	Gabbro	ND	68	15	80	42	182	ND	ND
01-RME-0101	613013	5189100	Ol leucogabbro	ND	55	ND	21	23	96	ND	ND
01-RME-0106	613663	5189800	Ol leucogabbro	ND	68	ND	52	46	144	ND	ND
01-RME-0113	613593	5189242	Ol leucogabbro	ND	50	ND	123	22	93	ND	ND
01-RME-0119	613417	5188293	Ol leucogabbro	ND	42	ND	13	14	45	ND	ND
01-RME-0121	614185	5189650	Ol leucogabbro	ND	57	6	20	49	168	ND	ND
01-RME-121-2	614185	5189650	Ol leucogabbro	ND	62	ND	20	57	213	ND	ND
01-RME-0124	614861	5190116	Ol leucogabbro	ND	84	6	29	96	546	ND	ND
Host Rocks											
01-RME-0008	612977	5187253	Gabbro	ND	13	ND	ND	11	ND	ND	ND
01-RME-0032	612985	5186643	Mafic gneiss	ND	98	ND	29	76	504	ND	ND
01-RME-0033	612844	5186450	Mafic gneiss	ND	51	18	22	36	227	ND	ND
01-RME-0046	612920	5187060	Bi-hb diorite gneiss	ND	14	ND	ND	9	ND	ND	ND
01-RME-0058	612378	5187395	Mafic gneiss	ND	62	248	48	102	167	ND	ND
01-RME-0102	613034	5189255	Bi-hb diorite gneiss	ND	48	ND	23	34	89	ND	ND
01-RME-0128	614618	5189639	Mafic gneiss	ND	92	ND	48	101	425	ND	ND
01-RME-0150	610792	5185535	Quartzose schist	ND	ND	16	ND	ND	25	ND	ND
01-RME-0170	610840	5188322	Bi-hb diorite gneiss	ND	14	ND	ND	11	ND	ND	ND

Abbreviations: ND = not detected, bi = biotite, fgr = fine grained, hb = hornblende, ol = olivine, rx = recrystallized.

Table 8. Assay data for rocks from the O'Connor magnetite occurrence. Detection limit for each element is listed in brackets under that element. Easting and northing are in UTM zone 17T, NAD 83.

O'Connor Occurrence	Easting	Northing	Co (5 ppm)	Cr (4 ppm)	Cu (5 ppm)	Fe [Fe_20_3] (0.01 wt. %)	TiO_2 (0.01 wt. %)	Total Fe_20_3 + TiO_2 (wt. %)	Ni (5 ppm)	V (5 ppm)	Au+Pd+Pt (ppb)
01-RME-0125	614861	5190221	296	ND	ND	39.80 [56.91]	22.72	79.63	337	2680	ND
Hurst (1932)	614860	5190220	NA	NA	NA	43.62 [62.36]	21.96	84.32	NA	1800	NA

Abbreviations: NA = not analyzed; ND = not detected.

Shklanka (1968) classified the occurrence as magmatic in origin and summarized previous information reported by Hurst (1932). Racicot and Keevil (1998) reported a resource estimate of 140 000 000 tonnes of 36% Fe and 15.6% TiO_2 for the occurrence, but the source or basis of this calculation is not provided. A contact metamorphic origin for the magnetite was suggested by Hurst (1932), in part based on the localization of the mineralization at the contact of the intrusion and the presence of magnetite in both the mafic intrusion and the country rocks. As noted previously, geochemical data collected by this study can be interpreted to indicate that country rocks (units 3 and 4) were affected by alkali metasomatism, consistent with a contact metamorphic or metasomatic origin of the magnetite.

ASSESSMENT OF MINERAL POTENTIAL

Copper – Nickel – Platinum Group Element Mineralization

Current models suggest that the following conditions must be met for the formation of magmatic copper–nickel–platinum group element (Cu–Ni–PGE) deposits (e.g., Lightfoot and Keays 1995): 1) the presence of sulphur-undersaturated magmas; 2) the presence of high-temperature, high-magnesium magmas, which are typically associated with mantle plumes; 3) sulphur-saturation of a previously sulphur-undersaturated magma, due to the assimilation of sulphide-bearing country rocks near the site of emplacement of the magma; and 4) the presence of physical traps to catch the sulphide mineral phases.

Unfortunately, most of these conditions may not be present for the Fanny Lake and Fall Lake intrusions. Their slightly alkalic and magnesium-poor character suggests low degrees of partial melting in the mantle source region, which reduces the sulphur capacity of the magma, possibly to the point of generating a sulphur-saturated magma (condition 1 not met). Furthermore, if the intrusions were related to a continental back-arc rifting event involving previously hydrated mantle source rocks, rather than to mantle–plume related flood basalt magmatism, then the likelihood of producing a large magmatic sulphide deposit is reduced (condition 2 not met). Thus, the first 2 conditions, which are critical to generating magmatic Cu–Ni–PGE deposits were probably not met. Finally, the third condition may be absent as well, given the quartzofeldspathic and sulphide-poor nature of the host rocks.

To date, analyses of 44 samples from the Fanny Lake and Fall Lake intrusions have not detected PGE concentrations above the detection limits for these elements (*see* Table 7). Nickel contents are generally low, even in olivine-rich rocks, consistent with the iron-rich and nickel-poor character of the analyzed olivines (*see* Appendix 2). No gossan or breccia zones have been reported from either intrusion, either by field party personnel or by Racicot and Keevil (1998). These observations, in concert with the fact that these intrusions do not seem to meet the critical conditions for the development of large, magmatic Cu–Ni–PGE deposits, would suggest that the Cu–Ni–PGE potential of these intrusions is relatively low.

Iron–Titanium–Vanadium and Chromium Mineralization

The presence of the O'Connor magnetite occurrence clearly indicates the presence of contact-related iron–titanium–vanadium (Fe–Ti–V) oxide mineralization in the Fall Lake intrusion. In contrast, as noted by Easton (2001), iron occurrences within the Fanny Lake intrusion are associated with melatroctolite layers (unit 7) and appear to result from serpentinization and alteration of the host rocks resulting in magnetite-rich veins and pods. Deposits formed in this manner are not likely to be of sufficient size to be prospective. Lower overall Ti and V contents in samples from the Fanny Lake intrusion (*see* Table 7; *see* Appendix 1) and the low magnetic susceptibility observed in units 8 and 9 of the intrusion (*see* Table 6), also suggest that it is less prospective for Fe–Ti–V mineralization than the Fall Lake intrusion. The Fanny Lake intrusion, however, may host significant magnetite mineralization within altered melatroctolite and related rocks of unit 7.

Chromium mineralization is unlikely in either intrusion, given the iron-rich character and low nickel contents of the intrusions, which is also reflected in their olivine compositions (*see* Table 7; *see* Appendix 2). This assessment is supported by the generally low chromium values observed in rocks from the Fanny Lake and Fall Lake intrusions (*see* Table 7; *see* Appendix 1).

Gold Mineralization

In the section "Discussion and Synthesis", it was noted that one tectonic scenario for the presence of Geon 12 mafic and felsic magmatism in Tomiko domain involves a combination of back-arc spreading and an upwelling mantle plume. Opplinger, Murphy and Brimhall (1997) have suggested such a model for the Cenozoic Columbia River Basalt Group, which also relates the development of Carlin-type gold deposits to the period of back-arc extension that occurs prior to the main period of flood basalt volcanism. If this model is in any way applicable to the Tomiko domain, then alteration zones associated with large fracture systems located near Geon 12 granitic plutons, such as the Mulock granite batholith, would be the favoured target in any gold exploration program. Given the proximity of the Geon 12 mafic magmatism to the Grenville Front, gold might also be expected along large fracture systems cutting Archean and Paleoproterozoic rocks in the adjacent Temagami greenstone belt and Cobalt Plate.

Building Stone

Proximity to the Ontario Northland Railway, immediately south of Fanny Lake, and an existing access road to the railroad west of Fanny Lake makes it feasible to consider the possible extraction of building stone from Flett Township. As noted by Racicot and Keevil (1998), a test block of leucotroctolite has already been taken from the Fanny Lake intrusion. Leucotroctolite from the Fanny Lake intrusion contains dark feldspars, is not highly jointed, contains minor sulphide minerals or other deleterious minerals, and would polish to produce a stone very similar to the Dana Black stone produced from the River Valley intrusion. The presence of amphibole coronas around olivine grains in the rock, however, would likely restrict usage of such a stone to indoor applications, in much the same way that amphibole coronas around orthopyroxene in the River Valley intrusion cause unacceptable weathering of the stone in outdoor environments. Leucocratic olivine gabbro from the Fall Lake intrusion, that lacks such coronas, might be a better prospect although it is slightly lighter in colour and is further from existing transportation links.

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Appendix 1:

Whole Rock Chemistry Data for Samples from Flett and Angus Townships

Appendix 1. Whole rock chemistry data from Flett and Angus townships. UTM co-ordinates are in zone 17, NAD83 datum.

Sample Number	Easting	Northing	Map Unit	Rock Type	SiO_2	TiO_2	Al_2O_3	Fe_2O_3 total	MnO	MgO	CaO
Country Rocks											
01RME-0008	612977	5187253	4	Bi-hb diorite gneiss	57.22	1.12	16.84	8.85	0.13	0.69	3.13
01RME-0032	612985	5186643	3	Mafic gneiss	39.13	6.47	15.72	22.71	0.21	4.15	6.07
01RME-0033	612844	5186450	3	Mafic gneiss	46.54	3.09	19.12	12.98	0.17	3.39	7.67
01RME-0046	612920	5187060	4	Bi-hb diorite gneiss	56.18	1.09	17.30	9.70	0.15	0.86	3.59
01RME-0058	612378	5187395	3	Mafic gneiss	45.37	2.03	17.88	13.96	0.18	7.00	8.66
01RME-0128	614618	5189639	3	Alt mafic gneiss	40.05	5.22	17.52	20.31	0.19	5.42	6.47
01RME-0150	610792	5185535	5	Quartzose schist	82.04	0.17	10.86	1.14	-0.01	0.50	0.15
01RME-0170	610840	5188322	4	Bi-hb diorite gneiss	55.80	1.54	14.76	12.78	0.24	0.54	4.47
Fall Lake intrusion											
01RME-0066	612678	5188162	11	Gabbro	41.94	5.16	14.13	19.68	0.26	5.08	6.17
01RME-0067	612630	5188300	11	Olivine gabbro	41.05	5.67	15.23	21.35	0.24	6.05	5.90
01RME-0072	612880	5188087	11	Gabbro	48.75	3.06	14.44	15.91	0.22	3.12	7.09
01RME-0075	613000	5188327	11	Fgr amphibolite	36.86	4.96	8.11	27.65	0.34	6.88	9.63
01RME-0101	613013	5189100	13	Olivine gabbro	45.51	3.95	17.29	14.13	0.18	3.43	7.27
01RME-0102	613034	5189255	11	Metagabbro	51.35	2.92	18.32	10.56	0.13	3.00	5.44
01RME-0106	613663	5189800	13	Leucogabbro	44.54	4.17	19.41	14.49	0.16	4.24	7.31
01RME-0113	613593	5189242	13	Leucogabbro	48.01	3.28	20.02	11.26	0.13	3.07	7.69
01RME-0121	614185	5189650	13	Leucogabbro	46.38	2.85	20.62	12.91	0.14	3.86	7.70
Fanny Lake intrusion											
01RME-0140	610556	5187061	11	Metagabbro	49.79	2.71	14.60	16.55	0.25	2.52	6.59
01RME-0142	610554	5186635	8	Metagabbro	42.00	4.77	14.22	17.53	0.17	6.47	9.42
01RME-0143	610600	5186298	9	Leucotroctolite	44.85	0.84	16.66	14.49	0.17	11.42	7.62
01RME-0144	610715	5186004	11	Gneissic gabbro	47.89	0.75	23.30	7.99	0.08	5.60	9.71
01RME-0166	610300	5186130	12	Gabbroic gneiss	49.58	2.19	19.94	11.22	0.12	3.40	7.74
01RME-0180	610910	5187010	9	Leucotroctolite	47.34	1.15	20.26	11.43	0.13	8.07	8.70
01RME-0188	611591	5188610	9	Leucotroctolite	45.24	0.69	19.17	11.37	0.13	10.64	9.11
01RME-0190	611572	5189022	8	Troctolite	47.64	1.21	20.90	10.42	0.12	7.22	9.38
01RME-0191	611630	5189340	9	Troctolite vein	43.46	0.10	17.42	12.87	0.14	15.24	7.90
01RME-0195	611777	5189362	7	Melatroctolite	35.79	0.55	2.76	24.36	0.26	29.73	1.42
01RME-0199	611984	5188956	7	Melatroctolite	40.61	0.63	11.43	18.16	0.20	18.19	5.08
01RME-0216	611230	5186510	7	Melatroctolite	40.05	0.58	8.65	20.77	0.23	22.75	3.98
01RME-0217	611089	5186188	7	Melatroctolite	36.13	0.80	3.17	24.67	0.23	25.71	1.60
01RME-0225	611227	5187403	7	Melatroctolite	40.96	0.35	12.17	17.32	0.19	18.61	5.29
01RME-0230	611062	5186836	8	Troctolite	42.43	0.72	13.72	16.65	0.19	16.70	6.18
01RME-0268	611607	5189654	7	Melatroctolite	43.43	0.39	16.14	15.29	0.17	14.71	7.17
01RME-0284	611488	5187777	7	Melatroctolite	36.16	0.38	3.14	24.22	0.25	28.65	1.34
01RME-0307	611330	5190653	9	Leucotroctolite	45.92	0.62	18.78	11.99	0.14	11.00	8.57
01RME-0313	611550	5188614	9	Leucotroctolite	47.74	1.36	21.50	9.37	0.11	7.15	9.95
01RME-0314	611550	5188614	9	Troctolite	42.74	0.95	13.00	18.31	0.21	17.17	5.85
01RME-0142-2	610586	5186640	8	Rusty gabbro boulder	42.50	4.54	12.16	21.18	0.28	4.73	7.99
01RME-0251	611719	5188950	9	Melatroctolite	32.17	0.33	1.83	24.54	0.25	27.55	0.24
01RME-0256	611190	5188996	8	Troctolite	44.57	5.44	14.18	16.33	0.18	5.68	9.54
01RME-0267	611580	5189850	8	Troctolite	42.63	0.33	14.81	15.84	0.18	16.43	6.63
01RME-0281	610875	5190668	9	Melatroctolite	34.03	0.23	6.19	22.14	0.18	23.47	1.40
01RME-0292	612276	5190319	8	Troctolite	42.84	1.94	11.72	19.70	0.22	13.12	5.53

Abbreviations: Alt = alteration, bi = biotite, fgr = fine-grained, hb = hornblende, NA = not analyzed.

Appendix 1. continued.

Sample Name	Na_2O	K_2O	P_2O_5	CO_2	S	LOI	Total	Mg No.	Cr	Ni	Co	Sc	V	Cu	Pb	Zn
Country Rocks																
01RME-0008	6.17	4.67	0.27	0.22	0.01	0.63	99.72	13.4	<4	11	13	13	<5	<5	11	116
01RME-0032	3.49	1.28	0.52	0.04	0.01	0.17	99.92	26.6	<4	76	98	18	504	29	12	219
01RME-0033	4.81	0.78	0.55	0.03	0.02	0.25	99.35	34.1	18	36	51	13	227	22	6	110
01RME-0046	6.32	3.75	0.29	0.08	<0.01	0.59	99.82	14.9	<4	9	14	16	<5	<5	12	130
01RME-0058	3.35	0.32	0.56	0.09	0.03	0.72	100.03	49.8	248	102	62	16	167	48	7	112
01RME-0128	3.40	0.74	0.27	0.12	0.05	0.06	99.65	34.6	<4	101	92	12	425	48	5	175
01RME-0150	0.39	3.95	0.03	0.10	<0.01	1.48	100.70	46.5	16	<5	-5	1	25	<5	<5	21
01RME-0170	5.25	3.41	0.45	0.10	0.01	0.24	99.48	7.7	<4	11	14	39	<5	<5	6	140
Fall Lake intrusion																
01RME-0066	4.05	1.80	0.54	0.06	0.14	0.23	99.04	33.8	<4	33	77	21	118	96	8	182
01RME-0067	3.51	1.05	0.35	0.08	0.14	<0.05	100.40	35.9	5	58	94	17	227	86	<5	186
01RME-0072	4.91	1.71	1.03	0.04	0.06	0.63	100.87	28.0	<4	14	39	33	19	6	13	165
01RME-0075	2.35	0.66	2.04	0.09	0.03	0.15	99.63	33.0	<4	22	79	52	74	<5	<5	243
01RME-0101	4.80	1.22	0.90	0.07	0.01	0.57	99.25	32.5	<4	23	55	17	96	21	7	135
01RME-0102	4.80	1.83	0.28	0.13	0.01	0.65	99.28	36.0	<4	34	48	8	89	23	12	114
01RME-0106	4.01	0.95	0.36	0.18	0.10	<0.05	99.64	36.7	<4	46	68	12	144	52	<5	123
01RME-0113	4.72	1.24	0.40	0.07	0.15	<0.05	99.82	35.1	<4	22	50	14	93	123	<5	100
01RME-0121	4.28	0.95	0.30	0.14	0.07	<0.05	99.99	37.2	6	49	57	9	168	20	<5	117
Fanny Lake intrusion																
01RME-0140	4.74	1.66	1.01	0.24	0.04	0.34	100.76	23.2	<4	14	30	42	<5	<5	5	147
01RME-0142	3.32	0.68	2.19	0.05	0.02	<0.05	100.77	42.2	<4	18	82	24	341	<5	<5	112
01RME-0143	2.97	0.49	0.19	0.05	0.05	<0.05	99.70	61.0	44	263	83	8	44	31	<5	104
01RME-0144	3.90	0.32	0.13	0.04	0.03	0.71	100.38	58.1	30	159	50	5	57	18	<5	55
01RME-0166	4.56	1.06	0.43	0.05	0.02	0.46	100.70	37.5	25	41	50	13	200	74	<5	104
01RME-0180	3.36	0.52	0.20	0.08	0.03	<0.05	101.16	58.3	69	207	67	9	107	18	<5	89
01RME-0188	2.80	0.39	0.14	0.07	0.02	<0.05	99.68	65.0	56	306	77	7	47	11	<5	86
01RME-0190	3.36	0.65	0.27	0.05	0.03	<0.05	101.17	57.8	55	150	59	10	73	23	<5	79
01RME-0191	2.08	0.17	0.02	0.08	<0.01	0.42	99.82	70.1	66	403	96	3	<5	<5	<5	83
01RME-0195	0.52	0.10	0.12	0.11	0.04	3.81	99.42	70.7	122	935	187	9	34	<5	<5	163
01RME-0199	1.78	0.31	0.12	0.10	0.03	3.38	99.89	66.5	78	518	118	9	41	<5	<5	130
01RME-0216	1.32	0.25	0.10	0.12	0.02	1.65	100.33	68.4	84	680	139	9	34	<5	<5	144
01RME-0217	0.13	<0.01	0.05	0.68	0.04	7.71	100.20	67.4	131	840	183	12	46	7	<5	149
01RME-0225	1.74	0.22	0.06	0.12	0.02	3.40	100.31	68.0	100	568	134	7	22	9	<5	125
01RME-0230	2.20	0.33	0.15	0.10	0.02	0.56	99.83	66.5	403	380	120	8	57	12	<5	121
01RME-0268	2.10	0.20	0.05	0.22	0.01	0.32	99.97	65.6	623	329	104	5	43	<5	<5	110
01RME-0284	0.47	0.09	0.10	0.17	0.02	5.46	100.26	70.1	111	912	186	8	20	<5	<5	160
01RME-0307	2.98	0.34	0.13	0.09	0.02	<0.05	100.47	64.5	56	288	83	7	40	11	<5	88
01RME-0313	3.27	0.56	0.18	0.05	0.04	-0.05	101.14	60.2	73	186	64	11	97	25	<5	79
01RME-0314	2.11	0.44	0.21	0.08	0.04	<0.05	100.99	65.0	86	456	123	9	59	25	<5	147
01RME-0142-2	3.49	1.09	1.89	NA	NA	0.15	100.00	30.7	<4	17	43	30	15	<5	NA	143
01RME-0251	0.03	0.04	0.11	NA	NA	12.03	99.12	69.0	82	659	128	6	10	<5	NA	192
01RME-0256	3.40	0.77	0.32	NA	NA	0.15	100.56	40.8	21	37	81	37	321	111	NA	119
01RME-0267	2.02	0.21	0.05	NA	NA	0.61	99.74	67.3	475	335	101	5	27	<5	NA	91
01RME-0281	0.48	0.08	0.04	NA	NA	11.08	99.32	67.7	77	583	132	5	8	<5	NA	71
01RME-0292	2.36	0.92	0.18	NA	NA	0.56	99.09	56.9	74	281	103	12	126	<5	NA	155

Abbreviations: Alt = alteration, bi = biotite, fgr = fine-grained, hb = hornblende, NA = not analyzed.

Appendix 1. continued.

Sample Name	Sn	Rb	Cs	Ba	Sr	Ga	Ta	Nb	Hf	Zr	Y	Th	U
Country Rocks													
01RME-0008	8	59	0.65	3817	286	41	1.31	27.8	8.43	381	39.0	3.96	0.79
01RME-0032	12	26	1.22	1119	444	45	1.19	22.6	5.01	210	34.0	1.76	0.42
01RME-0033	11	9	0.36	562	748	35	0.58	11.4	2.23	97	21.0	0.92	0.24
01RME-0046	10	47	0.69	4115	423	40	0.87	19.5	6.8	301	31.0	3.18	0.63
01RME-0058	7	7	0.35	339	622	28	0.42	8.8	1.3	52	18.0	0.45	0.11
01RME-0128	9	14	0.74	720	527	34	0.64	11.9	2.46	107	15.4	0.81	0.20
01RME-0150	<5	161	3.54	522	27	27	0.36	4.1	1.82	72	1.8	3.92	0.52
01RME-0170	<5	30	1.01	5819	345	35	0.56	12.0	4.72	222	34.0	2.26	0.45
Fall Lake intrusion													
01RME-0066	11	72	4.54	932	358	35	1.4	26.0	4.97	209	31.0	1.88	0.43
01RME-0067	6	16	0.39	858	456	35	1.04	19.2	3.72	158	21.0	1.32	0.33
01RME-0072	13	28	0.67	1376	465	35	1.09	21.5	5.48	233	42.3	2.23	0.50
01RME-0075	9	12	0.42	512	186	30	0.82	15.6	4.41	170	55.5	1.75	0.43
01RME-0101	9	22	0.67	1218	552	37	1.27	24.2	4.88	210	35.1	2.02	0.54
01RME-0102	<5	59	3.31	997	559	29	0.77	12.4	2.62	105	13.2	4.14	0.78
01RME-0106	<5	13	0.3	774	600	35	0.86	15.4	2.99	131	17.6	1.10	0.28
01RME-0113	10	17	0.41	920	606	36	0.76	14.3	3.36	146	21.4	1.31	0.35
01RME-0121	6	14	0.29	768	678	37	0.62	12.0	2.79	128	17.9	1.17	0.31
Fanny Lake intrusion													
01RME-0140	<5	22	0.33	1665	632	34	0.41	10.1	3.13	164	32.5	1.59	0.33
01RME-0142	<5	7	0.12	628	502	29	0.45	7.5	2.12	65	28.1	0.64	0.14
01RME-0143	<5	6	0.11	367	498	25	<0.30	4.9	1.38	36	10.0	0.48	0.12
01RME-0144	<5	5	0.21	184	729	27	<0.30	4.0	0.84	12	6.5	0.33	0.08
01RME-0166	<5	13	0.29	824	645	35	0.31	7.7	1.93	81	16.6	0.95	0.18
01RME-0180	<5	6	0.14	385	599	27	<0.30	5.2	1.28	36	9.9	0.45	0.11
01RME-0188	<5	4	0.15	297	595	25	<0.30	3.6	0.91	22	7.5	0.34	0.09
01RME-0190	<5	8	0.13	436	605	27	0.38	7.1	1.88	56	14.2	0.73	0.19
01RME-0191	<5	1	0.07	158	524	18	<0.30	0.5	<0.10	3	0.5	<0.05	<0.01
01RME-0195	<5	2	0.12	98	62	7	<0.30	2.1	0.62	23	4.5	0.17	0.05
01RME-0199	<5	3	0.07	222	327	16	<0.30	2.6	0.81	20	6.0	0.24	0.06
01RME-0216	<5	3	0.29	170	242	13	<0.30	2.5	0.78	21	5.3	0.26	0.06
01RME-0217	<5	0	0.07	29	35	8	<0.30	3.4	0.82	35	6.7	0.20	0.06
01RME-0225	<5	2	0.06	143	379	15	<0.30	1.4	0.39	3	3.1	0.13	0.03
01RME-0230	<5	4	0.11	253	423	19	<0.30	3.3	0.93	24	6.6	0.34	0.09
01RME-0268	<5	2	0.07	195	468	18	<0.30	1.2	0.31	3	2.6	0.11	0.04
01RME-0284	<5	1	0.12	88	78	6	<0.30	1.5	0.47	16	3.6	0.16	0.04
01RME-0307	<5	4	0.06	280	535	23	<0.30	3.1	0.83	16	6.4	0.33	0.08
01RME-0313	<5	6	0.27	378	625	29	<0.30	5.3	1.49	39	10.7	0.43	0.12
01RME-0314	<5	7	0.12	315	379	21	<0.30	5.6	1.54	55	10.9	0.57	0.15
01RME-0142-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
01RME-0251	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
01RME-0256	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
01RME-0267	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
01RME-0281	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
01RME-0292	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Abbreviations: Alt = alteration, bi = biotite, fgr = fine-grained, hb = hornblende, NA = not analyzed.

Appendix 1. continued.

Sample Name	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	ΣREE
Country Rocks															
01RME-0008	35.71	78.12	11.12	44.34	9.12	5.05	8.30	1.29	7.38	1.55	4.33	0.65	4.32	0.71	212.0
01RME-0032	20.13	44.49	7.06	31.21	7.12	2.58	7.20	1.13	6.56	1.38	3.70	0.55	3.33	0.54	137.0
01RME-0033	18.97	43.90	6.30	26.88	5.57	2.41	5.22	0.76	4.21	0.84	2.18	0.31	1.78	0.29	119.6
01RME-0046	39.04	82.79	10.91	42.01	8.07	4.06	7.04	1.10	5.96	1.20	3.24	0.49	3.11	0.54	209.6
01RME-0058	17.60	39.23	5.56	23.40	4.71	1.96	4.43	0.65	3.44	0.71	1.83	0.25	1.43	0.23	105.4
01RME-0128	14.18	31.58	4.37	18.07	3.82	1.90	3.48	0.54	2.97	0.60	1.59	0.24	1.46	0.23	85.0
01RME-0150	3.92	7.02	0.95	3.28	0.53	0.11	0.39	0.06	0.30	0.06	0.17	0.03	0.24	0.04	17.1
01RME-0170	18.64	49.29	7.42	35.05	8.33	5.50	7.77	1.14	6.69	1.34	3.77	0.54	3.54	0.56	149.6
Fall Lake intrusion															
01RME-0066	25.12	55.73	8.12	33.65	7.30	2.62	6.95	1.06	6.04	1.22	3.39	0.50	3.05	0.51	155.3
01RME-0067	19.13	41.32	5.75	23.46	4.78	2.22	4.53	0.68	3.97	0.82	2.23	0.34	2.11	0.33	111.7
01RME-0072	30.06	72.84	11.62	50.86	11.32	3.70	10.56	1.57	8.49	1.70	4.34	0.64	3.75	0.59	212.0
01RME-0075	47.49	107.22	17.11	77.01	16.57	4.00	15.94	2.20	11.80	2.28	5.70	0.76	4.29	0.68	313.1
01RME-0101	27.25	63.37	9.12	38.91	8.49	3.14	8.33	1.25	6.87	1.38	3.69	0.54	3.18	0.51	176.0
01RME-0102	20.70	43.25	4.93	18.18	3.33	1.44	3.14	0.47	2.58	0.52	1.39	0.20	1.27	0.20	101.6
01RME-0106	16.39	36.65	5.04	20.88	4.31	2.36	4.12	0.61	3.46	0.70	1.88	0.28	1.75	0.28	98.7
01RME-0113	20.85	45.36	6.29	25.79	5.40	2.78	4.88	0.74	4.06	0.81	2.23	0.34	2.07	0.32	121.9
01RME-0121	17.38	38.21	5.23	21.26	4.33	2.32	4.03	0.62	3.39	0.70	1.89	0.28	1.70	0.27	101.6
Fanny Lake intrusion															
01RME-0140	17.98	48.82	8.00	38.49	9.04	4.49	8.40	1.20	6.51	1.26	3.31	0.46	2.72	0.42	151.1
01RME-0142	21.98	53.83	8.11	38.64	8.36	2.73	8.09	1.02	5.37	0.99	2.46	0.30	1.86	0.28	154.0
01RME-0143	8.35	18.57	2.51	10.78	2.28	1.05	2.05	0.29	1.77	0.36	1.02	0.15	0.92	0.15	50.3
01RME-0144	6.95	15.07	1.92	7.81	1.58	1.07	1.39	0.22	1.22	0.24	0.66	0.09	0.73	0.08	39.0
01RME-0166	18.51	40.78	5.44	22.25	4.36	1.94	4.04	0.55	3.12	0.62	1.63	0.24	1.42	0.21	105.1
01RME-0180	8.56	19.27	2.62	11.20	2.33	1.20	2.14	0.32	1.88	0.39	1.10	0.16	0.93	0.16	52.3
01RME-0188	6.67	14.64	1.99	8.65	1.66	1.00	1.62	0.24	1.36	0.29	0.78	0.11	0.73	0.11	39.8
01RME-0190	11.86	27.04	3.64	15.61	3.39	1.39	3.20	0.46	2.70	0.54	1.46	0.22	1.45	0.20	73.2
01RME-0191	1.5	2.65	0.32	1.16	0.20	0.48	0.12	0.02	0.10	0.02	0.08	0.01	0.09	0.02	6.8
01RME-0195	3.12	7.31	1.01	4.43	0.98	0.33	0.96	0.14	0.89	0.18	0.51	0.07	0.48	0.08	20.5
01RME-0199	4.72	10.40	1.41	6.21	1.33	0.73	1.27	0.19	1.14	0.23	0.69	0.10	0.62	0.09	29.1
01RME-0216	4.23	9.34	1.23	5.42	1.15	0.54	1.14	0.16	0.99	0.21	0.58	0.08	0.60	0.10	25.8
01RME-0217	2.78	7.54	1.15	5.30	1.33	0.34	1.36	0.20	1.18	0.25	0.81	0.11	0.75	0.12	23.2
01RME-0225	2.97	6.26	0.81	3.52	0.69	0.52	0.66	0.09	0.58	0.12	0.35	0.05	0.37	0.06	17.0
01RME-0230	5.88	13.34	1.78	7.34	1.63	0.84	1.49	0.21	1.31	0.26	0.79	0.11	0.71	0.11	35.8
01RME-0268	2.9	6.04	0.79	3.23	0.58	0.56	0.54	0.08	0.46	0.10	0.28	0.04	0.25	0.05	15.9
01RME-0284	2.69	6.02	0.85	3.42	0.84	0.28	0.75	0.11	0.66	0.14	0.43	0.06	0.36	0.07	16.7
01RME-0307	5.77	12.82	1.72	7.35	1.42	0.88	1.34	0.20	1.24	0.24	0.72	0.09	0.58	0.10	34.5
01RME-0313	7.99	18.60	2.50	10.98	2.41	1.23	2.39	0.35	2.07	0.42	1.16	0.16	1.05	0.16	51.5
01RME-0314	9.4	21.56	2.89	12.09	2.42	0.97	2.18	0.34	2.02	0.43	1.15	0.18	1.21	0.17	57.0
01RME-0142-2															
01RME-0251															
01RME-0256															
01RME-0267															
01RME-0281															
01RME-0292															

Abbreviations: Alt = alteration, bi = biotite, fgr = fine-grained, hb = hornblende, NA = not analyzed.

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Appendix 2:

Mineral Chemistry Data for Samples from Flett and Angus Townships

Appendix 2. Mineral chemistry data for samples from Flett and Angus townships. Quality control data at end of listing is cross-referenced to the job number associated with each analysis. Jobs 01-0272 and 01-0339 were based on energy-dispersive (EDS) quantitative analysis with a ZAF correction using the JOEL scanning electron microscope. Job 01-0380 used the CAMECA electron microprobe.

Sample Number	anal. #	job #	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	V_2O_5	NiO	Total
Olivine															
01RME-0067 olivine	em69	272	32.68	0.00	0.10	49.74	0.85	15.85	0.03	0.31	0.00	0.04	0.00	0.00	99.59
01RME-0067 olivine	em70	272	32.81	0.00	0.19	50.19	0.67	15.86	0.06	0.10	0.01	0.03	0.01	0.02	99.94
01RME-0067 olivine	em71	272	32.96	0.00	0.00	49.58	0.73	15.96	0.00	0.00	0.00	0.05	0.00	0.05	99.32
01RME-0067 olivine	em72	272	32.69	0.00	0.07	50.78	0.73	15.08	0.04	0.45	0.00	0.00	0.02	0.08	99.93
01RME-0067 olivine	em77	272	33.57	0.04	0.36	51.07	0.85	16.01	0.01	0.19	0.04	0.00	0.04	0.00	102.18
01RME-0067 olivine	em78	272	33.68	0.01	0.85	51.08	0.87	16.36	0.07	0.07	0.00	0.04	0.00	0.00	103.03
01RME-0067 matrix olivine	em79	272	33.85	0.06	0.20	51.00	0.87	16.85	0.02	0.12	0.04	0.00	0.00	0.00	103.02
01RME-0121 olivine	em16	272	33.52	0.01	0.00	47.08	0.75	18.56	0.02	0.00	0.00	0.00	0.00	0.00	99.95
01RME-0121 olivine	em17	272	35.01	0.00	0.07	46.00	0.63	20.59	0.04	0.16	0.00	0.00	0.03	0.04	102.57
01RME-0121 olivine	em20	272	35.23	0.10	0.16	49.50	0.72	18.82	0.10	0.06	0.00	0.00	0.00	0.00	104.68
01RME-0121 olivine	em24	272	34.02	0.04	0.08	46.21	0.70	18.69	0.29	0.19	0.00	0.04	0.01	0.00	100.26
01RME-0121 olivine	em26	272	33.81	0.13	0.20	49.12	0.65	17.00	0.01	0.14	0.02	0.04	0.00	0.00	101.11
01RME-0121 olivine	em31	272	34.22	0.00	0.10	44.73	0.65	20.36	0.00	0.03	0.05	0.04	0.08	0.00	100.24
01RME-0180 olivine (rim)	em100	339	35.68	0.00	0.06	33.48	0.43	29.00	0.00	0.06	0.00	0.04	0.05	0.05	98.85
01RME-0180 olivine (core)	em101	339	35.68	0.08	0.02	33.31	0.46	28.43	0.41	0.00	0.00	0.00	0.03	0.02	98.44
01RME-0180 olivine (core)	em104	339	35.60	0.06	0.00	34.30	0.45	28.66	0.10	0.19	0.00	0.05	0.00	0.12	99.55
01RME-0180 olivine (rim)	em105	339	35.76	0.06	0.00	34.77	0.45	28.15	0.00	0.00	0.01	0.02	0.00	0.04	99.25
01RME-0180 olivine (core)	em114	339	35.89	0.09	0.25	35.52	0.53	27.86	0.00	0.09	0.00	0.00	0.01	0.06	100.30
01RME-0180 olivine (rim)	em115	339	35.96	0.02	0.07	36.00	0.50	27.76	0.01	0.19	0.00	0.00	0.03	0.02	100.55
01RME-0180 olivine (core)	em118	339	36.18	0.00	0.00	32.64	0.40	29.57	0.20	0.25	0.03	0.06	0.00	0.13	99.48
01RME-0180 olivine (rim)	em119	339	36.11	0.07	0.15	33.34	0.41	30.35	0.01	0.00	0.03	0.00	0.10	0.21	100.78
01RME-0180 olivine (core)	em128	339	36.79	0.13	0.19	31.73	0.24	30.44	0.56	0.39	0.00	0.05	0.00	0.03	100.55
01RME-0180 olivine (rim)	em129	339	36.47	0.00	0.00	32.16	0.41	30.92	0.06	0.00	0.00	0.00	0.05	0.09	100.16
01RME-0188 olivine (core)	em144	339	36.47	0.00	0.83	29.96	0.40	31.81	0.03	0.30	0.04	0.04	0.00	0.11	99.97
01RME-0180 olivine (rim)	em145	339	36.61	0.02	1.26	29.93	0.38	31.98	0.03	0.13	0.00	0.00	0.04	0.11	100.49
01RME-0188 olivine (core)	em180	339	34.46	0.00	0.11	35.54	0.37	27.12	0.08	0.00	0.00	0.03	0.00	0.16	97.86
01RME-0190 olivine (rim)	em181	339	34.69	0.04	0.21	35.78	0.36	27.08	0.00	0.21	0.06	0.01	0.00	0.14	98.56
01RME-0190 olivine (core)	em188	339	35.85	0.00	0.20	37.77	0.40	26.99	0.00	0.00	0.00	0.01	0.03	0.10	101.36
01RME-0190 olivine (rim)	em189	339	35.65	0.02	0.07	37.66	0.41	26.79	0.03	0.00	0.04	0.01	0.01	0.21	100.91
01RME-0190 olivine (core)	em196	339	36.61	0.08	0.15	36.81	0.53	29.16	0.04	0.07	0.04	0.00	0.00	0.09	103.59
01RME-0190 olivine (rim)	em197	339	53.28	0.00	1.07	20.75	0.45	23.94	0.14	0.12	0.00	0.05	0.00	0.00	99.79
01RME-0191 olivine (core)	em216	339	36.52	0.05	0.06	29.01	0.26	33.15	0.02	0.16	0.01	0.00	0.00	0.15	99.38
01RME-0191 olivine (rim)	em217	339	36.26	0.09	0.08	29.12	0.23	32.77	0.03	0.00	0.04	0.01	0.00	0.18	98.79
01RME-0191 olivine (core)	em218	339	36.03	0.12	0.02	28.13	0.32	33.38	0.06	0.53	0.02	0.00	0.05	0.18	98.83
01RME-0191 olivine (rim)	em219	339	36.26	0.03	0.00	27.77	0.27	32.84	0.03	0.27	0.00	0.00	0.04	0.20	97.70
01RME-0191 olivine	em225	339	35.99	0.06	0.08	27.13	0.26	33.04	0.04	0.00	0.00	0.04	0.01	0.09	96.73
01RME-0191 olivine	em226	339	36.57	0.08	0.03	27.67	0.34	34.07	0.06	0.12	0.02	0.00	0.00	0.20	99.14
01RME-0191 olivine (core)	em227	339	36.24	0.00	0.00	29.29	0.31	32.56	0.09	0.22	0.00	0.04	0.10	0.08	98.91
01RME-0191 olivine (rim)	em228	339	36.50	0.09	0.04	28.82	0.33	32.89	0.19	0.05	0.03	0.01	0.00	0.06	98.99
01RME-0191 olivine (core)	em233	339	36.50	0.04	0.00	28.02	0.31	33.89	0.03	0.00	0.02	0.01	0.00	0.08	98.89
01RME-0195 olivine (core)	em156	339	36.09	0.05	0.01	27.44	0.37	33.95	0.07	0.31	0.00	0.07	0.00	0.13	98.49
01RME-0195 olivine (rim)	em157	339	36.09	0.10	0.32	26.95	0.35	33.61	0.20	0.04	0.02	0.08	0.02	0.11	97.88
01RME-0195 olivine (core)	em160	339	36.69	0.04	0.21	26.72	0.34	33.43	0.23	0.22	0.00	0.00	0.04	0.20	98.10
01RME-0195 olivine (rim)	em161	339	36.12	0.04	0.00	26.80	0.34	33.34	0.03	0.00	0.00	0.03	0.00	0.14	96.83
01RME-0195 olivine (core)	em162	339	35.70	0.06	1.02	26.55	0.39	33.60	0.25	0.26	0.01	0.00	0.03	0.11	97.97
01RME-0195 olivine (rim)	em163	339	36.16	0.11	0.07	26.79	0.33	33.84	0.00	0.02	0.00	0.00	0.00	0.15	97.47
01RME-0195 olivine (core)	em176	339	37.08	0.08	0.00	26.73	0.34	34.73	0.00	0.00	0.00	0.00	0.02	0.05	99.04
01RME-0195 olivine (rim)	em177	339	37.09	0.02	0.00	27.09	0.30	35.28	0.00	0.00	0.01	0.03	0.04	0.22	100.08
01RME-0195 olivine	em178	339	36.81	0.00	0.09	26.93	0.30	34.95	0.04	0.30	0.00	0.02	0.00	0.09	99.51
01RME-0195 olivine	em179	339	36.62	0.00	0.20	26.79	0.34	35.56	0.05	0.08	0.00	0.03	0.02	0.09	99.77

Appendix 2. continued.

Sample Number	anal. #	job #	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	V_2O_5	NiO	Total
Olivine															
01RME-0199 olivine (core)	cm234	339	34.91	0.00	0.04	28.87	0.33	30.47	0.19	0.29	0.01	0.04	0.00	0.15	95.29
01RME-0199 olivine (rim)	cm235	339	34.72	0.06	0.18	28.70	0.37	30.83	0.04	0.00	0.01	0.00	0.00	0.13	95.02
01RME-0199 olivine (core)	cm236	339	34.72	0.07	0.02	29.14	0.41	30.61	0.10	0.00	0.00	0.01	0.07	0.11	95.25
01RME-0199 olivine (rim)	cm237	339	34.91	0.02	0.15	29.60	0.45	30.89	0.04	0.00	0.00	0.00	0.00	0.13	96.17
01RME-0199 olivine (core)	cm238	339	34.90	0.00	0.13	28.75	0.37	30.83	0.02	0.00	0.02	0.00	0.07	0.08	95.17
01RME-0199 olivine (rim)	cm239	339	34.79	0.04	0.05	28.68	0.35	30.48	0.22	0.00	0.00	0.00	0.00	0.14	94.74
01RME-0199 olivine	cm253	339	35.64	0.02	0.11	30.89	0.41	29.94	0.00	0.00	0.00	0.00	0.03	0.00	97.04
01RME-0199 olivine	cm254	339	35.09	0.05	0.08	30.32	0.32	31.00	0.02	0.09	0.00	0.03	0.00	0.15	97.14
Pyroxene															
01RME-0121 pyroxene	cm32	272	50.21	1.62	3.76	10.16	0.20	11.72	21.85	0.91	0.00	0.05	0.11	0.00	100.59
01RME-0121 pyroxene	cm33	272	48.64	2.47	5.50	9.65	0.18	10.50	22.14	0.83	0.00	0.09	0.02	0.04	100.06
01RME-0180 (core)	cm108	339	48.97	2.11	3.62	9.65	0.11	12.93	20.85	0.52	0.00	0.02	0.11	0.03	98.92
01RME-0180 (rim)	cm109	339	49.05	2.01	3.94	9.33	0.12	12.44	21.44	0.58	0.00	0.08	0.10	0.00	99.08
01RME-0180 (core)	cm120	339	48.72	2.18	4.10	9.20	0.14	13.26	20.66	0.76	0.02	0.06	0.20	0.00	99.29
01RME-0180 (rim)	cm121	339	50.41	1.55	3.87	8.64	0.11	12.95	21.89	0.84	0.00	0.04	0.15	0.01	100.45
01RME-0188 (core)	cm137	339	49.54	1.41	4.35	7.79	0.15	13.30	21.68	0.76	0.00	0.03	0.09	0.09	99.19
01RME-0188 (rim)	cm138	339	49.09	1.60	4.19	8.16	0.12	13.01	21.55	0.22	0.00	0.06	0.00	0.00	97.99
01RME-0188 (core)	cm146	339	48.89	2.24	4.75	8.09	0.13	13.27	21.55	0.46	0.00	0.05	0.12	0.00	99.54
01RME-0188 (rim)	cm147	339	48.08	2.22	5.28	7.79	0.19	12.82	21.79	0.41	0.00	0.00	0.16	0.09	98.82
01RME-0190 (core)	cm191	339	51.33	1.17	3.18	8.77	0.15	13.22	22.54	0.51	0.00	0.00	0.10	0.00	100.96
01RME-0190 (rim)	cm192	339	51.35	1.12	2.98	9.02	0.21	12.60	23.21	0.91	0.00	0.01	0.00	0.00	101.41
01RME-0190 (core)	cm202	339	49.04	2.09	4.15	9.67	0.15	12.00	21.97	0.80	0.00	0.00	0.21	0.00	100.07
01RME-0190 (rim)	cm204	339	51.19	1.14	9.14	8.03	0.13	10.33	19.18	1.87	0.39	0.10	0.00	0.07	101.56
Corona Phases															
01RME-0180	cm102	339	52.96	0.02	0.43	19.43	0.49	25.06	0.22	0.00	0.04	0.00	0.00	0.00	98.65
01RME-0180	cm106	339	54.04	0.05	0.33	20.06	0.41	24.93	0.19	0.00	0.01	0.07	0.00	0.00	100.09
01RME-0180	cm116	339	53.08	0.01	0.25	20.14	0.37	24.51	0.39	0.00	0.00	0.09	0.00	0.06	98.91
01RME-0188	cm130	339	54.06	0.01	1.40	19.16	0.43	25.33	0.18	0.06	0.01	0.00	0.03	0.00	100.66
01RME-0190	cm182	339	52.31	0.03	0.54	20.47	0.43	23.91	0.21	0.05	0.00	0.03	0.07	0.01	98.05
01RME-0190	cm200	339	53.15	0.00	0.45	21.45	0.40	23.33	0.48	0.00	0.00	0.04	0.00	0.00	99.30
01RME-0191	cm220	339	52.27	0.02	0.81	16.87	0.38	25.77	0.26	0.17	0.00	0.04	0.00	0.05	96.65
01RME-0195	cm159	339	36.50	0.00	0.00	26.83	0.34	33.40	0.04	0.00	0.02	0.05	0.10	0.21	97.48
01RME-0199	cm242	339	53.37	0.01	0.45	17.76	0.41	25.73	0.24	0.29	0.00	0.05	0.00	0.01	98.31
Garnet															
01RME-0127 in amphibole	cm60*	272	39.59	0.01	23.96	35.10	1.30	4.33	3.76	0.02	0.00	0.00	0.09	0.03	108.18
01RME-0128 small	cm7	272	37.64	0.02	22.63	32.74	1.05	4.30	3.77	0.06	0.03	0.00	0.06	0.01	102.31
01RME-0128 matrix	cm14	272	37.20	0.00	22.22	31.45	0.93	4.03	4.39	0.00	0.00	0.09	0.09	0.00	100.39
01RME-0180 in corona	cm103	339	37.32	0.06	20.76	11.12	0.03	12.39	10.86	2.83	1.48	0.04	0.01	0.05	96.94
01RME-0180 in corona	cm107	339	38.96	0.24	18.97	10.67	0.04	12.50	11.25	2.85	1.77	0.06	0.00	0.04	97.35
01RME-0180 in corona	cm117	339	36.64	0.00	21.40	11.56	0.13	12.84	10.48	2.48	1.53	0.00	0.00	0.00	97.07
01RME-0188 in corona	cm131	339	40.18	0.10	18.68	10.42	0.16	13.47	11.24	3.06	0.84	0.05	0.00	0.08	98.28
01RME-0188 in corona	cm132	339	38.35	0.00	23.88	24.82	1.43	8.97	3.65	0.00	0.00	0.06	0.00	0.00	101.16
01RME-0188 in corona	cm133	339	38.01	0.00	22.98	24.74	1.52	8.65	4.28	0.08	0.03	0.00	0.05	0.09	100.42
01RME-0188 in corona	cm136	339	35.68	0.00	25.58	25.91	1.27	9.22	3.04	0.03	0.00	0.01	0.03	0.18	100.93
01RME-0188 garnet	cm150	339	38.29	0.04	22.98	24.58	1.22	6.60	7.03	0.00	0.04	0.04	0.00	0.00	100.82
01RME-0190 in corona	cm183	339	37.53	0.00	19.07	11.33	0.16	12.29	10.87	3.13	1.27	0.07	0.08	0.06	95.85
01RME-0190 in corona	cm184	339	37.92	0.02	22.93	25.62	1.88	8.14	3.73	0.00	0.00	0.00	0.00	0.00	100.25
01RME-0190 in corona	cm195	339	38.77	0.05	23.43	23.03	1.67	6.15	9.26	0.00	0.19	0.02	0.01	0.08	102.66
01RME-0190 garnet	cm199	339	36.06	0.00	25.16	25.84	1.58	8.24	3.81	0.15	0.05	0.00	0.00	0.00	100.88
01RME-0191 in corona	cm221	339	36.66	0.14	21.30	9.15	0.11	14.63	10.29	2.48	0.55	0.05	0.03	0.12	95.50
01RME-0191 in corona	cm222	339	37.22	0.17	22.42	19.23	1.23	7.62	9.88	0.00	0.74	0.00	0.00	0.00	98.51
01RME-0195 in corona	cm158	339	40.11	0.11	17.70	7.15	0.04	14.35	11.15	3.12	0.54	0.01	0.00	0.00	94.27
01RME-0199 in corona	cm243	339	40.40	0.11	14.71	11.07	0.13	15.83	6.22	1.64	3.40	0.01	0.00	0.00	93.51

Appendix 2. continued.

Sample Number	Anal. #	job #	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	V_2O_5	NiO	Total
Oxide Minerals															
01RME-0008 ilmenite	cm87	272	0.13	49.43	0.00	44.81	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.05	96.15
01RME-0008 ilmenite	cm93	272	0.15	51.07	0.13	46.31	1.72	0.04	0.01	0.15	0.08	0.08	0.00	0.00	99.72
01RME-0067 ilmenite	cm81	272	0.19	52.04	0.68	46.76	0.62	0.79	0.00	0.00	0.01	0.07	0.00	0.00	101.16
01RME-0067 ilmenite	cm75	272	0.08	53.02	0.01	47.09	0.57	0.94	0.00	0.09	0.00	0.13	0.24	0.05	102.20
01RME-0067 ilmenite**	cm76	272	0.17	56.21	0.04	49.85	0.75	0.74	0.03	0.00	0.00	0.08	0.00	0.00	107.86
01RME-0075 magnetite	cm39	272	0.14	0.97	0.30	93.44	0.01	0.09	0.02	0.60	0.01	0.00	0.25	0.00	95.84
01RME-0075 ilmenite	cm36	272	0.20	51.19	0.36	48.82	0.77	0.18	0.00	0.05	0.00	0.00	0.00	0.00	101.57
01RME-0075 ilmenite (core)	cm40	272	0.16	51.72	0.17	48.50	0.79	0.19	0.00	0.10	0.00	0.02	0.00	0.00	101.65
01RME-0075 ilmenite	cm44	272	0.07	50.97	0.13	47.12	0.75	0.12	0.00	0.27	0.00	0.01	0.00	0.00	99.44
01RME-0121 ilmenite	cm29	272	0.20	54.40	0.00	46.59	0.72	0.79	0.00	0.06	0.01	0.07	0.00	0.00	102.83
01RME-0121 Fe oxide	cm30	272	0.27	7.59	4.72	82.92	0.00	0.50	0.03	0.20	0.00	0.05	1.01	0.01	97.29
01RME-0127 ilmenite	cm62	272	0.15	48.00	0.63	50.98	0.32	0.09	0.00	0.29	0.00	0.00	0.08	0.00	100.55
01RME-0127 ilmenite	cm63	272	0.22	48.33	0.60	51.24	0.22	0.09	0.00	0.09	0.00	0.01	0.10	0.09	100.98
01RME-0128 in opaque	cm5	272	0.24	0.98	0.25	89.04	0.01	0.19	0.01	0.06	0.02	0.00	0.69	0.09	91.57
01RME-0128 ilmenite	cm6	272	0.21	49.73	0.09	49.35	0.28	0.23	0.05	0.19	0.00	0.00	0.00	0.05	100.18
01RME-0128 in opaque	cm10	272	0.09	0.32	0.74	91.96	0.05	0.05	0.01	0.23	0.02	0.08	0.63	0.07	94.25
01RME-0128 ilmenite	cm11	272	0.25	49.80	0.64	49.87	0.10	0.08	0.00	0.00	0.05	0.07	0.00	0.02	100.88
01RME-0180 ilmenite (core)	cm110	339	0.23	52.19	0.12	44.66	0.59	1.81	0.00	0.00	0.04	0.02	0.06	0.00	99.71
01RME-0180 Fe oxide (rim)	cm111	339	0.34	1.15	0.95	87.34	0.00	0.17	0.04	0.00	0.04	1.29	2.71	0.05	94.07
01RME-0188 ilmenite	cm139	339	0.18	51.32	0.21	46.60	0.39	2.01	0.03	0.14	0.04	0.10	0.13	0.07	101.23
01RME-0188 spinel	cm152	339	0.10	0.14	58.84	29.39	0.19	9.56	0.04	0.15	0.01	1.27	0.30	0.23	100.21
01RME-0188 ilmenite	cm153	339	0.18	51.31	0.49	47.13	0.36	1.68	0.02	0.45	0.02	0.00	0.22	0.00	101.85
01RME-0190 ilmenite	cm185	339	0.08	52.06	0.32	47.58	0.39	1.26	0.03	0.00	0.00	0.00	0.31	0.09	102.10
01RME-0190 ilmenite	cm203	339	0.57	51.35	0.41	47.23	0.44	0.31	0.13	0.15	0.03	0.00	0.16	0.14	100.90
01RME-0191 opaque	cm223	339	0.12	6.51	4.55	71.84	0.38	0.97	0.00	0.00	0.04	10.94	1.23	0.06	96.64
01RME-0191 ilmenite	cm224	339	0.00	53.05	0.09	44.44	0.64	2.12	0.00	0.00	0.05	0.10	0.37	0.00	100.87
01RME-0195 ilmenite	cm173	339	0.05	53.82	0.41	43.34	0.64	2.31	0.02	0.00	0.00	0.08	0.18	0.00	100.86
01RME-0199 ilmenite needle in Fe oxide	cm252	339	0.57	48.80	0.74	45.15	0.73	1.91	0.00	0.08	0.00	0.08	0.06	0.09	98.22
01RME-0199 ilmenite	cm259	339	0.06	51.85	0.28	44.99	0.57	1.40	0.03	0.00	0.00	0.03	0.03	0.17	99.40
Biotite															
01RME-0008 biotite (core)	cm86	272	32.27	5.35	11.44	32.30	0.16	1.51	0.03	0.00	8.67	0.02	0.00	0.00	91.75
01RME-0008 biotite	cm89	272	32.92	5.36	11.60	33.57	0.21	1.44	0.01	0.09	8.78	0.03	0.01	0.02	94.02
01RME-0008 biotite	cm95	272	35.95	2.89	12.76	32.87	0.16	2.63	0.04	0.00	8.66	0.00	0.00	0.04	96.00
01RME-0075 biotite	cm43	272	36.16	2.66	14.35	21.40	0.01	10.46	0.27	0.38	7.78	0.00	0.00	0.02	93.49
01RME-0121 with olivine	cm25	272	36.58	6.31	14.65	15.68	0.03	13.13	0.01	0.00	10.31	0.00	0.00	0.00	96.70
01RME-0127 biotite, matrix	cm54	272	36.31	2.69	17.34	19.07	0.08	12.44	0.06	0.82	8.61	0.00	0.00	0.00	97.41
01RME-0127 biotite, matrix	cm55	272	36.72	2.43	17.80	19.35	0.00	13.04	0.09	0.80	8.85	0.00	0.00	0.06	99.14
01RME-0128 biotite, matrix	cm8	272	38.15	1.42	16.62	17.68	0.04	10.99	5.88	1.30	3.95	0.02	0.10	0.08	96.22
01RME-0188 in corona	cm134	339	36.49	5.06	15.63	11.01	0.05	16.58	0.06	0.26	10.05	0.00	0.04	0.12	95.33
01RME-0188 in corona	cm135	339	35.38	4.57	16.13	11.42	0.07	15.67	0.02	0.41	9.64	0.00	0.13	0.12	93.56
01RME-0188 biotite	cm151	339	35.94	5.27	17.47	11.73	0.00	16.04	0.02	0.00	10.13	0.04	0.16	0.00	96.80
01RME-0190 biotite	cm186	339	41.26	3.82	11.30	15.58	0.11	17.55	0.06	0.43	7.26	0.03	0.00	0.03	97.41
01RME-0190 biotite	cm187	339	38.02	4.94	15.11	12.85	0.00	16.04	0.06	0.38	10.10	0.08	0.08	0.00	97.65
01RME-0190 biotite	cm190	339	36.20	6.13	15.24	15.45	0.00	13.40	0.08	0.06	9.79	0.00	0.00	0.04	96.39
01RME-0190 with olivine	cm201	339	39.18	0.18	17.35	11.95	0.05	14.10	9.96	2.32	3.05	0.00	0.00	0.00	98.14
01RME-0199 with olivine	cm240	339	36.19	4.93	14.24	9.39	0.06	16.71	0.01	0.00	10.01	0.07	0.00	0.11	91.72
01RME-0199 with olivine	cm241	339	36.44	4.90	14.26	9.63	0.41	17.03	0.01	0.47	10.02	0.00	0.15	0.10	93.42
01RME-0199 in corona	cm260	339	35.29	6.62	14.46	11.14	0.05	14.45	0.05	0.00	9.88	0.04	0.10	0.08	92.16

Appendix 2. continued.

Sample Number	anal. #	job #	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	V_2O_5	NiO	Total
Amphibole															
01RME-0008 core*	cm83	272	44.38	1.63	0.67	21.06	0.46	3.98	18.79	0.01	0.00	0.00	0.00	0.00	90.97
01RME-0008 core*	cm84	272	45.94	0.86	0.78	18.81	0.62	5.51	19.16	0.71	0.07	0.00	0.06	0.00	92.50
01RME-0008 core*	cm85	272	47.62	0.37	0.62	19.35	0.66	5.40	19.62	0.79	0.04	0.00	0.00	0.02	94.49
01RME-0008 *	cm88	272	45.73	0.01	0.57	25.08	0.87	1.59	17.46	0.91	0.06	0.32	0.09	0.00	92.69
01RME-0008 oxidized	cm96	272	48.91	0.00	2.73	29.06	0.36	1.32	0.06	0.00	0.03	0.00	0.00	0.08	82.56
01RME-0008 amphibole	cm97	272	49.17	0.00	0.97	26.16	1.00	2.41	18.74	1.21	0.07	0.00	0.10	0.00	99.83
01RME-0008 amphibole*	cm99	272	49.61	0.07	0.70	24.04	0.78	3.67	20.24	1.22	0.00	0.00	0.04	0.00	100.35
01RME-0075 in opaque	cm34	272	43.84	0.91	9.25	24.83	0.33	7.79	8.68	2.61	0.39	0.02	0.03	0.00	98.65
01RME-0075 in matrix	cm35	272	44.03	1.04	9.20	24.58	0.39	7.81	8.80	2.47	0.38	0.00	0.05	0.00	98.74
01RME-0075 in opaque	cm37	272	43.64	1.19	9.72	24.52	0.31	8.02	8.98	3.25	0.39	0.00	0.10	0.10	100.22
01RME-0075 in matrix	cm38	272	44.87	0.95	7.70	26.08	0.28	8.04	7.76	2.67	0.35	0.08	0.00	0.00	98.77
01RME-0075 aggregate	cm41	272	44.90	1.06	9.09	23.69	0.25	8.37	9.50	3.33	0.49	0.06	0.03	0.00	100.76
01RME-0075 crystal	cm42	272	43.84	1.03	8.79	23.77	0.30	8.01	8.75	2.78	0.42	0.07	0.42	0.00	98.17
01RME-0075 in matrix	cm45	272	43.28	1.06	8.81	24.60	0.38	7.98	8.94	2.50	0.42	0.06	0.04	0.00	98.06
01RME-0075 in matrix	cm46	272	43.97	0.98	8.31	24.56	0.36	7.87	8.41	2.69	0.42	0.02	0.00	0.06	97.65
01RME-0075 amphibole	cm47	272	47.27	0.41	5.01	27.98	0.55	9.37	4.35	1.82	0.16	0.03	0.07	0.00	97.01
01RME-0075 amphibole	cm48	272	42.74	1.04	9.03	24.11	0.27	7.43	9.14	2.62	0.43	0.00	0.02	0.00	96.84
01RME-0121 with olivine	cm18	272	50.46	2.18	4.17	10.76	0.21	11.92	22.52	0.34	0.01	0.00	0.00	0.01	102.58
01RME-0121	cm21	272	53.30	1.46	3.32	10.79	0.24	12.87	23.04	0.79	0.02	0.00	0.03	0.00	105.85
01RME-0127 in matrix	cm49	272	36.91	0.00	21.77	31.84	1.24	4.11	4.25	0.17	0.00	0.01	0.02	0.00	100.31
01RME-0127 in matrix	cm50	272	37.29	0.07	22.07	32.22	1.27	4.26	4.11	0.10	0.01	0.13	0.00	0.02	101.53
01RME-0127 type 1, matrix	cm51	272	41.29	0.72	15.80	19.05	0.12	8.68	10.10	2.66	0.38	0.00	0.14	0.01	98.94
01RME-0127 type 1, matrix	cm52	272	40.75	0.76	15.75	19.11	0.07	8.67	10.13	2.73	0.47	0.06	0.18	0.00	98.67
01RME-0127 type 2	cm53	272	41.66	0.70	15.75	19.09	0.14	8.92	10.18	2.55	0.49	0.14	0.10	0.06	99.78
01RME-0127 type 2	cm56	272	43.43	0.80	16.57	20.08	0.15	8.68	10.64	2.46	0.52	0.00	0.22	0.00	103.55
01RME-0127 type 1	cm57	272	41.55	0.75	16.19	19.57	0.04	8.72	10.07	2.14	0.46	0.09	0.18	0.03	99.78
01RME-0127 type 1	cm58	272	42.27	0.81	16.14	19.77	0.04	8.93	10.33	2.47	0.40	0.00	0.13	0.09	101.38
01RME-0127 type 2	cm59	272	42.57	0.81	16.52	19.73	0.04	9.18	10.61	2.31	0.46	0.00	0.17	0.00	102.40
01RME-0128 hornblende	cm1	272	40.69	0.80	15.66	18.43	0.05	8.96	9.66	2.24	0.42	0.00	0.21	0.10	97.21
01RME-0128 hornblende	cm2	272	36.44	0.00	21.59	32.42	1.10	3.93	3.42	0.00	0.01	0.03	0.05	0.07	99.06
01RME-0128 hornblende	cm3	272	40.59	0.80	15.43	18.26	0.03	8.59	10.15	2.65	0.47	0.08	0.23	0.07	97.34
01RME-0128 hornblende	cm4	272	40.90	0.69	15.31	18.29	0.02	8.76	10.13	2.35	0.43	0.01	0.20	0.09	97.17
01RME-0128 hornblende	cm12	272	39.74	0.60	15.48	17.87	0.02	8.96	10.30	2.44	0.37	0.00	0.09	0.00	95.87
Alkali Feldspar															
01RME-0008 K-feldspar	cm98	272	64.23	0.26	19.45	0.09	0.08	0.00	0.06	0.95	15.03	0.00	0.00	0.00	100.15
01RME-0008 K-feldspar	cm94	272	63.76	0.42	18.84	0.00	0.00	0.01	0.01	1.29	14.87	0.02	0.00	0.00	99.21
01RME-0008 core	cm90	272	62.27	0.75	19.03	0.00	0.06	0.00	0.00	1.08	14.38	0.00	0.00	0.06	97.63
01RME-0008 core	cm91	272	62.02	0.66	19.01	0.02	0.00	0.10	0.01	1.26	14.39	0.00	0.00	0.02	97.48
01RME-0008 rim	cm92	272	66.86	0.06	20.45	0.06	0.01	0.00	0.27	11.46	0.08	0.00	0.01	0.00	99.26
01RME-0127 by cm65	cm64	272	61.40	0.06	24.29	0.36	0.00	0.00	3.24	6.29	4.86	0.04	0.00	0.00	100.55
Plagioclase Feldspar															
01RME-0067 plagioclase	cm82	272	55.71	0.04	28.02	0.13	0.00	0.17	11.39	6.46	0.09	0.03	0.00	0.00	102.03
01RME-0067 blade	cm80	272	56.65	0.21	29.97	0.23	0.00	0.00	10.11	6.29	0.11	0.00	0.00	0.00	103.58
01RME-0067 plagioclase	cm73	272	54.87	0.13	29.31	0.62	0.00	0.03	9.52	6.36	0.06	0.03	0.04	0.03	100.99
01RME-0067 plagioclase	cm74	272	55.64	0.14	29.68	0.07	0.00	0.00	9.69	6.88	0.13	0.05	0.00	0.05	102.34
01RME-0121 in matrix	cm27	272	59.79	0.10	27.03	0.01	0.00	0.01	7.06	7.99	0.40	0.03	0.00	0.00	102.43
01RME-0121 in matrix	cm28	272	56.59	0.14	29.37	0.16	0.00	0.07	9.98	6.36	0.24	0.00	0.00	0.03	102.93
01RME-0121 plagioclase	cm22	272	59.64	0.21	31.18	0.27	0.00	0.10	9.61	5.65	1.65	0.03	0.00	0.00	108.34
01RME-0121 plagioclase	cm23	272	60.31	0.26	31.43	0.11	0.08	0.06	10.88	6.02	0.27	0.00	0.07	0.02	109.51
01RME-0121 plagioclase	cm19	272	57.47	0.17	30.14	0.13	0.00	0.00	10.44	6.28	0.23	0.02	0.08	0.00	104.96
01RME-0127 plagioclase	cm61	272	65.69	0.09	26.19	0.09	0.00	0.00	5.16	9.38	0.00	0.07	0.03	0.03	106.73
01RME-0127 plagioclase	cm65	272	62.90	0.02	25.07	0.29	0.03	0.00	4.78	9.18	0.05	0.01	0.02	0.00	102.35
01RME-0127 plagioclase	cm66	272	61.25	0.00	25.46	0.26	0.02	0.03	5.22	8.61	0.02	0.06	0.00	0.02	100.94
01RME-0127 large lath	cm67	272	61.79	0.01	25.42	0.19	0.00	0.13	5.26	8.66	0.07	0.02	0.00	0.00	101.55
01RME-0127 large lath	cm68	272	62.17	0.03	25.24	0.07	0.00	0.00	4.99	8.70	0.07	0.12	0.06	0.00	101.44

Appendix 2. continued.

Sample Number	**anal. #**	**job #**	**SiO_2**	**TiO_2**	**Al_2O_3**	**FeO**	**MnO**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**Cr_2O_3**	**V_2O_5**	**Total**
Plagioclase Feldspar														
01RME-0128 plagioclase	cm9	272	61.53	0.04	25.64	0.09	0.01	0.08	5.23	8.22	0.00	0.00	0.00	100.90
01RME-0128 plagioclase	cm13	272	60.57	0.00	25.63	0.04	0.00	0.05	5.26	8.41	0.03	0.08	0.02	100.08
01RME-0128 in matrix	cm15	272	60.42	0.05	24.99	0.12	0.00	0.00	5.03	8.30	0.03	0.00	0.00	98.94
01RME-0180 plagioclase **	cm112	339	53.75	0.13	28.26	0.29	0.00	0.04	10.92	4.99	0.16	0.00	0.04	98.57
01RME-0180 plagioclase **	cm113	339	53.90	0.10	27.42	0.28	0.08	0.21	10.32	5.72	0.17	0.00	0.12	98.31
01RME-0180 plagioclase **	cm122	339	53.08	0.11	28.76	0.37	0.00	0.00	11.70	4.87	0.23	0.00	0.01	99.13
01RME-0180 plagioclase	cm123	339	53.77	0.18	29.18	0.29	0.06	0.04	11.48	5.10	0.18	0.00	0.00	100.28
01RME-0180 plagioclase **	cm124	339	51.48	0.18	29.14	0.51	0.13	0.33	12.60	3.96	0.25	0.00	0.00	98.58
01RME-0180 plagioclase	cm125	339	51.55	0.15	29.14	0.39	0.00	0.00	12.49	3.85	0.23	0.00	0.00	97.82
01RME-0180 plagioclase **	cm126	339	53.48	0.12	28.64	0.17	0.04	0.19	11.75	5.06	0.12	0.11	0.00	99.66
01RME-0180 plagioclase	cm127	339	52.91	0.18	28.83	0.27	0.00	0.20	11.58	5.05	0.24	0.06	0.00	99.32
01RME-0188 plagioclase	cm141	339	50.69	0.04	29.87	0.23	0.03	0.08	13.67	3.78	0.08	0.03	0.00	98.50
01RME-0188 plagioclase	cm143	339	50.62	0.08	29.51	0.33	0.06	0.00	13.19	3.17	0.12	0.06	0.00	97.15
01RME-0188 plagioclase	cm149	339	52.44	0.06	28.82	0.51	0.01	0.14	11.85	4.11	0.16	0.08	0.00	98.17
01RME-0188 plagioclase	cm155	339	53.83	0.17	27.80	0.41	0.00	0.00	11.00	5.15	0.17	0.00	0.00	98.54
01RME-0190 plagioclase	cm193	339	54.58	0.21	29.04	0.29	0.01	0.00	11.92	4.94	0.14	0.00	0.00	101.13
01RME-0190 plagioclase	cm206	339	52.33	0.16	28.69	0.34	0.05	0.09	12.07	4.73	0.22	0.11	0.00	98.79
01RME-0190 plagioclase	cm207	339	54.58	0.15	27.89	0.24	0.00	0.09	10.81	5.37	0.41	0.00	0.00	99.54
01RME-0191 core	cm209	339	51.83	0.06	29.34	0.17	0.00	0.13	12.63	3.96	0.08	0.00	0.12	98.31
01RME-0191 rim	cm211	339	50.57	0.07	29.57	0.24	0.02	0.03	13.50	3.80	0.12	0.05	0.01	97.99
01RME-0191 plagioclase	cm213	339	51.13	0.16	30.13	0.15	0.00	0.11	13.12	4.17	0.04	0.00	0.00	99.01
01RME-0191 plagioclase	cm215	339	50.68	0.16	30.02	0.13	0.00	0.00	13.46	3.94	0.05	0.00	0.00	98.44
01RME-0191 core****	cm230	339	48.53	0.12	28.01	2.18	0.11	2.73	11.32	3.47	0.02	0.00	0.00	96.48
01RME-0191 rim	cm232	339	51.67	0.16	30.23	0.25	0.00	0.23	13.12	4.04	0.04	0.05	0.00	99.80
01RME-0195 core	cm165	339	51.89	0.01	30.71	0.33	0.00	0.15	13.15	3.92	0.04	0.00	0.00	100.19
01RME-0195 rim****	cm167	339	52.04	0.05	31.94	0.58	0.00	0.30	13.54	4.08	0.07	0.05	0.00	102.64
01RME-0195 core****	cm169	339	53.14	0.12	31.87	0.25	0.01	0.16	14.00	4.19	0.05	0.00	0.00	103.79
01RME-0195 rim	cm172	339	50.61	0.10	30.73	0.78	0.00	0.36	12.45	4.45	0.09	0.00	0.00	99.56
01RME-0195 plagioclase	cm175	339	63.30	0.14	22.55	0.19	0.00	0.00	4.01	9.41	0.02	0.05	0.00	99.67
01RME-0199 core	cm245	339	51.96	0.06	29.66	0.11	0.06	0.00	12.42	3.94	0.50	0.03	0.00	98.74
01RME-0199 core	cm247	339	56.78	0.17	26.47	0.17	0.02	0.08	9.03	5.94	0.18	0.02	0.00	98.87
01RME-0199 core	cm249	339	51.90	0.15	29.63	0.20	0.00	0.00	12.82	4.49	0.03	0.11	0.00	99.33
01RME-0199 rim	cm251	339	56.16	0.15	25.94	0.19	0.00	0.00	8.66	6.27	0.13	0.00	0.00	97.49
01RME-0199 core	cm256	339	50.17	0.11	27.79	0.51	0.06	0.21	13.79	4.20	0.44	0.10	0.00	97.37
01RME-0199 rim	cm258	339	53.62	0.11	28.39	0.19	0.01	0.13	11.46	4.65	0.08	0.06	0.00	98.70

Sample Number	**anal. #**	**job #**	**SiO_2**	**TiO_2**	**Al_2O_3**	**FeO**	**CaO**	**Na_2O**	**K_2O**	**SrO**	**BaO**	**Total**
Plagioclase Feldspar												
01RME-0121	cm1	380	59.093	0.136	26.184	0.049	7.794	7.169	0.221	0.075	0.133	100.854
01RME-0121	cm2	380	58.879	0.088	26.287	0.076	7.948	7.259	0.197	0.125	0.162	101.021
01RME-0121	cm3	380	55.725	0.122	27.682	0.188	9.662	5.595	0.769	0.191	0.233	100.167
01RME-0121	cm5	380	57.386	0.112	26.619	0.495	8.475	6.356	0.446	0.262	0.211	100.362
01RME-0121	cm6	380	55.952	0.143	28.328	0.064	10.213	5.899	0.204	0.323	0.076	101.202
01RME-0121	cm7	380	55.544	0.154	28.006	0.164	9.836	5.870	0.264	0.254	0.087	100.179
01RME-0121	cm8	380	58.970	0.049	25.741	0.060	7.142	7.510	0.286	0.146	0.100	100.004
01RME-0121	cm9	380	56.767	0.096	26.706	0.041	8.551	6.613	0.359	0.131	0.122	99.386
01RME-0121	cm10	380	57.377	0.149	26.799	0.138	8.791	6.618	0.296	0.091	0.103	100.362
01RME-0067	cm11	380	55.915	0.119	28.052	0.459	9.263	6.426	0.099	0.104	0.108	100.545
01RME-0067	cm12	380	55.393	0.088	28.018	1.093	8.976	6.310	0.192	0.161	0.116	100.347
01RME-0067	cm13	380	57.074	0.133	26.617	0.431	8.619	6.707	0.124	0.131	0.046	99.882
01RME-0121##	cm4	380	51.627	0.138	25.699	3.988	7.899	5.451	0.311	0.249	0.003	95.365

Comments: *inclusions or cracks; **client analysis at 120,000 times magnification; ***contamination from adjacent grains; ****beam current too high; ## low total probably due to point of analysis

Appendix 2. continued.

Quality Control Job 01-0272

Standard	**anal. #**	**SiO_2**	**TiO_2**	**Al_2O_3**	**FeO**	**MnO**	**MgO**	**CaO**	**Na_2O**	**K_2O**	**Cr_2O_3**	**V_2O_5**	**NiO**	**Total**
Fe_2O_3std	s1217	0.31	0.07	0.32	89.90	0.00	0.00	0.05	0.06	0.00	0.00	0.00	0.00	90.71
Fe_2O_3std	s1277	0.13	0.00	0.09	90.06	0.07	0.24	0.01	0.28	0.05	0.04	0.04	0.00	91.03
Fe_2O_3std	s1287	0.22	0.00	0.28	89.94	0.00	0.07	0.00	0.15	0.00	0.03	0.13	0.01	90.82
Fe_2O_3std	s677	0.08	0.00	0.34	89.93	0.00	0.06	0.00	0.27	0.02	0.00	0.09	0.02	90.81
Fe_2O_3std	s87	0.17	0.03	0.27	89.94	0.00	0.01	0.00	0.32	0.01	0.07	0.00	0.00	90.82
$MnTiO_3$std	s1218	0.19	52.15	0.22	0.00	48.25	0.00	0.00	0.00	0.00	0.16	0.00	0.07	101.03
$MnTiO_3$std	s1278	0.15	53.37	0.17	0.00	46.88	0.04	0.00	0.06	0.00	0.10	0.00	0.07	100.83
$MnTiO_3$std	s1288	0.17	53.13	0.22	0.00	47.00	0.05	0.00	0.02	0.00	0.03	0.00	0.00	100.62
$MnTiO_3$std	s678	0.19	52.94	0.19	0.00	46.99	0.15	0.07	0.00	0.00	0.06	0.00	0.08	100.67
$MnTiO_3$std	s88	0.29	52.85	0.18	0.02	47.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	100.34
AmpKNZ	s12113	40.04	4.83	15.01	10.74	0.11	12.40	10.18	2.63	2.10	0.01	0.10	0.00	98.14
AmpKNZ	s12713	40.62	4.95	15.14	10.84	0.17	12.81	10.08	2.70	2.25	0.06	0.06	0.02	99.70
AmpKNZ	s12813	40.21	4.93	14.85	10.67	0.05	12.45	10.04	2.57	2.07	0.00	0.00	0.04	97.86
AmpKNZ	s6713	39.96	4.89	14.85	10.84	0.11	12.05	10.15	2.65	2.11	0.01	0.06	0.00	97.69
AmpKNZ	s813	40.14	4.89	14.88	10.82	0.03	12.40	10.16	2.53	2.07	0.07	0.05	0.03	98.06
OliOGC	s12115	40.49	0.00	0.01	8.66	0.12	49.75	0.08	0.22	0.00	0.02	0.00	0.52	99.86
OliOGC	s12715	40.87	0.00	0.06	8.51	0.14	50.14	0.01	0.06	0.00	0.00	0.07	0.27	100.12
OliOGC	s12815	40.98	0.01	0.00	8.66	0.12	50.15	0.10	0.00	0.02	0.04	0.00	0.36	100.44
OliOGC	s6715	40.53	0.00	0.16	8.57	0.07	49.81	0.02	0.38	0.02	0.03	0.00	0.46	100.06
OliOGC	s815	40.92	0.02	0.09	8.51	0.19	49.35	0.04	0.33	0.00	0.00	0.00	0.42	99.86

Standard	**OliOGC**	**$MnTiO_3$**	**ampKNZ**	**Fe_2O_3**	**$MnTiO_3$**	**OliOGC**	**ampKNZ**	**ampKNZ**	**ampKNZ**
Average wt %	40.757	52.888	14.945	89.955	47.225	49.839	10.122	2.616	2.121
Expected wt % *	40.370	52.980	14.900	89.980	47.030	49.940	10.100	2.600	2.100
Trueness % rel.	0.959	-0.174	0.302	-0.028	0.415	-0.202	0.218	0.631	1.019
Mode	EDS	EDS	EDS	EDS	EDS	EDS	EDS	EDS	EDS
Count time (seconds)	100	100	100	100	100	100	100	100	100

Analytical Conditions: 20kV, 2nA. **Routine:** General Routine – EDS acquisition. **Correction Procedure:** ZAF-4.
*Expected values from characterization of in-house mineral standards. **Client analysis at 120,000 times magnification. Quality Control notes. 1. None of the reported values for in-house standards are certified. "Trueness" is therefore based on available chemical data. 2. L.O.D. = limit of detection, precision approximately +/- 100%. 3. Limit of detection is determined by the instrument software for each individual analysis, and is defined as 3 times the standard deviation of the background.

Quality Control Job 01-0380

Sample	**SiO_2**	**TiO_2**	**Al_2O_3**	**FeO**	**CaO**	**Na_2O**	**K_2O**	**SrO**	**BaO**	**Total**
albff	69.020	0.000	19.371	0.002	0.050	11.907	0.070	0.040	0.000	100.460
albff	68.275	0.000	19.191	0.008	0.029	11.581	0.063	0.110	0.029	99.286
Standard	albFF		albFF			albFF	or1		or1	
Average wt %	68.648	LOD	19.281	LOD	0.040	11.744	n.d.	LOD	n.d.	
Expected wt % *	68.740		19.440		n.d.	11.820	15.120		0.890	
Trueness rel %	-0.135		-0.818			-0.643				
Mode	WDS	WDS	WDS	WDS	WDS	WDS	WDS	WDS	WDS	
XTAL	TAP	LiF	TAP	LiF	PET	TAP	PET	PET	PET	
Line	Ka	Ka	Ka	Ka	Ka	Ka	Ka	LA	La	
L.O.D. wt %	0.038	0.063	0.040	0.035	0.027	0.056	0.029	0.077	0.062	
L.O.Q. wt %	0.127	0.210	0.133	0.117	0.090	0.187	0.097	0.257	0.207	
Count time (seconds)	10	20	10	20	10	20	10	10	10	
Beam current (nA)	10	10	10	10	10	10	10	10	10	

Analytical Conditions: 20kV, 10nA, beam diameter approximately 10 microns. **Routine:** Feldspar Routine – WDS acquisition. **Correction Procedure:** PAP. **Important note:** Due to variations in L.O.D. and L.O.Q. with sample matrix, these values are approximated in this report. L.O.D.'s for EDS data represent the best case scenario (i.e. no peak overlaps). Precision is best when data exceed the L.O.Q. *Expected values from characterization of in-house mineral standards. **Client analysis at 120,000 times magnification. Quality Control notes. 1. None of the reported values for in-house standards are certified. "Trueness" is therefore based on available chemical data. 2. n.d. = not determined for the specified mineral standard. 3. L.O.D. = limit of detection, precision approximately +/- 100%. 4. L.O.Q = limit of quantification (3.3 times L.O.D.), precision approximately 10-30%. 5. Reported count times are for both peak and background measurements. 6. FeO* = total iron expressed as FeO.

Appendix 2. continued.

Quality Control Job 01-0339

Standard	anal. #	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Cr_2O_3	V_2O_5	NiO	Total
Fe_2O_3std	s3397	0.31	0.01	0.20	90.01	0.00	0.20	0.06	0.03	0.00	0.03	0.00	0.00	90.83
Fe_2O_3std	s1887	0.14	0.00	0.30	89.79	0.00	0.19	0.00	0.00	0.04	0.02	0.11	0.00	90.58
Fe_2O_3std	s1957	0.26	0.01	0.31	89.89	0.00	0.00	0.00	0.33	0.00	0.05	0.00	0.08	90.93
Fe_2O_3std	s1907	0.19	0.02	0.21	89.90	0.00	0.02	0.03	0.13	0.00	0.00	0.00	0.09	90.60
Fe_2O_3std	s1917	0.12	0.00	0.14	89.35	0.05	0.24	0.03	0.24	0.05	0.00	0.06	0.04	90.30
Fe_2O_3std	s1997	0.20	0.11	0.32	89.66	0.00	0.03	0.06	0.38	0.05	0.00	0.00	0.00	90.80
$MnTiO_3$std	s3398	0.18	53.03	0.22	0.01	47.03	0.17	0.00	0.06	0.00	0.00	0.00	0.00	100.70
$MnTiO_3$std	s1888	0.13	52.61	0.29	0.16	46.96	0.10	0.03	0.11	0.00	0.00	0.22	0.00	100.60
$MnTiO_3$std	s1958	0.08	52.87	0.34	0.20	47.09	0.28	0.00	0.10	0.00	0.00	0.00	0.03	100.99
$MnTiO_3$std	s1908	0.25	52.86	0.23	0.00	46.77	0.07	0.02	0.00	0.00	0.00	0.09	0.07	100.34
$MnTiO_3$std	s1918	0.12	52.73	0.36	0.26	46.59	0.19	0.00	0.13	0.00	0.00	0.01	0.00	100.39
$MnTiO_3$std	s1998	0.20	52.62	0.33	0.01	46.87	0.00	0.00	0.00	0.00	0.02	0.01	0.05	100.11
ampKNZ	s33913	40.19	5.02	14.90	10.93	0.08	12.72	10.07	2.57	2.19	0.06	0.00	0.00	98.72
ampKNZ	s18813	40.39	4.98	15.10	10.69	0.12	12.89	9.95	2.73	2.14	0.00	0.00	0.00	98.98
ampKNZ	s19513	39.64	5.04	14.96	11.30	0.07	12.43	10.07	2.61	2.14	0.00	0.07	0.02	98.35
ampKNZ	s19013	39.99	5.04	15.12	10.85	0.09	12.29	10.06	2.51	2.10	0.00	0.05	0.03	98.13
ampKNZ	s19114	40.28	4.87	15.10	10.60	0.11	12.22	10.09	2.67	2.15	0.02	0.09	0.04	98.24
ampKNZ	s19914	40.15	4.93	15.16	10.65	0.05	12.82	10.23	2.57	2.12	0.00	0.14	0.05	98.84
OliOGC	s33915	40.49	0.00	0.10	8.75	0.10	50.29	0.07	0.14	0.01	0.03	0.11	0.42	100.50
OliOGC	s18815	40.64	0.05	0.06	8.57	0.12	50.26	0.03	0.14	0.00	0.00	0.05	0.33	100.24
OliOGC	s19515	40.63	0.02	0.07	8.58	0.23	49.93	0.08	0.30	0.01	0.03	0.01	0.31	100.19
OliOGC	s19015	40.10	0.00	0.11	8.77	0.04	50.02	0.05	0.05	0.00	0.06	0.04	0.48	99.72
OliOGC	s19016	40.91	0.00	0.04	8.78	0.08	50.19	0.07	0.04	0.00	0.04	0.00	0.38	100.54
OliOGC	s19916	40.69	0.00	0.13	8.50	0.21	50.19	0.09	0.20	0.01	0.05	0.00	0.46	100.54
albite std	s33914	67.00	0.11	19.49	0.28	0.01	0.00	0.55	9.68	2.62	0.03	0.00		99.75
albite std	s18814	67.36	0.06	19.61	0.19	0.00	0.21	0.55	9.63	2.62	0.00	0.00		100.22
albite std	s19514	67.34	0.07	19.61	0.19	0.00	0.00	0.55	9.72	2.66	0.03	0.00		100.17
albite std	s19014	67.29	0.12	19.55	0.16	0.04	0.00	0.56	9.61	2.62	0.00	0.00		99.94
albite std	s19115	67.22	0.05	19.43	0.17	0.01	0.00	0.51	9.67	2.57	0.00	0.00		99.65

Standard	albite	albite	albite	albite	albite
Average	67.242	19.537	0.544	9.661	2.617
Expected*	67.427	19.528	0.551	9.682	2.602
Trueness rel %	-0.274	0.047	-1.199	-0.221	0.588
Mode	EDS	EDS	EDS	EDS	EDS
Count time	100	100	100	100	100

Standard	OliOGC	OliOGC	ampKNZ	$MnTiO_3$	Fe_2O_3	$MnTiO_3$	ampKNZ	ampKNZ	ampKNZ
Average wt %	50.137	40.556	10.049	52.819	89.785	46.888	2.142	2.619	15.036
Expected wt % *	49.940	40.370	10.100	52.980	89.980	47.030	2.100	2.600	14.900
Trueness % rel.	0.394	0.462	-0.503	-0.304	-0.216	-0.302	2.019	0.738	0.914
Mode	EDS	EDS	EDS	EDS	EDS	EDS	EDS	EDS	EDS
Count time (seconds)	100	100	100	100	100	100	100	100	100

Analytical Conditions: 20kV, 2nA. **Routine:** General Routine – EDS acquisition. **Correction Procedure:** ZAF-4. *Expected values from characterization of in-house mineral standards. **Client analysis at 120,000 times magnification. Quality Control notes. 1. None of the reported values for in-house standards are certified. "Trueness" is therefore based on available chemical data. 2. L.O.D. = limit of detection, precision approximately ±100%. 3. Limit of detection is determined by the instrument software for each individual analysis, and is defined as 3 times the standard deviation of the background.

Appendix 3:

Summary of Magnetic Susceptibility Measurements Collected within the Study Area, Grouped with respect to Map Unit

Appendix 3. Summary of magnetic susceptibility measurements collected within the study area, grouped with respect to map unit. Reading units are dimensional, and represent 10^{-3} times the SI unit for susceptibility.

Map unit	Station (prefex 01-RME-)	Lowest Reading	Highest Reading	Number of Readings	Average	Comment
Mafic gneiss (unit 3)	0032	0.96	1.31	10	1.09	
	0033	0.76	0.98	10	0.85	
	0044	0.97	1.29	5	1.13	
	0045	0.98	1.66	10	1.14	
	0096	0.69	1.28	3	0.87	
	0098	0.59	1.47	5	1.03	
	0099	0.92	1.45	8	1.18	
	0108	0.95	1.55	6	1.47	
	0109 light	0.93	1.36	4	1.12	
	0109 dark	1.32	1.55	4	1.45	
	0118	0.36	0.59	9	0.49	
	0127	2.70	11.6	5	5.8	Marginal to Fall Lake intrusion
	0128	7.14	23.5	5	12.7	
Biotite-hornblende Diorite gneiss (unit 4)	0008	0.53	0.62	4	0.58	Freshest sample of this map unit
	0020	0.40	0.77	10	0.52	
	0046	0.52	0.66	10	0.56	
	0085	0.33	0.43	4	0.37	
	0133	0.62	0.91	4	0.80	
	0135	0.60	0.83	7	0.70	
	0170	0.74	0.97	7	0.85	
Metasedimentary rocks (unit 5)	0149	3.35	9.06	4	7.1	Conglomerate
		1.55	16.0	2		granite
		4.94	10.9	4	6.9	conglomerate
	0150	0.00	0.13	9	0.03	Quartzose schist
	0151	0.80	16.8	8	8.7	Migmatite (metaconglomerate?)
	0183	0.05	0.13	3	0.1	Conglomerate to breccia
		3.10	14.5	6	7.8	
Gneissic granite (unit 6)	0010	0.00	0.01	8	0.01	
		1.30	2.75	2	2.1	
	0027	0.02	0.1	5	0.05	
		1.23	3.70	3	2.4	
	0040 grey	0.03	0.17	5	0.11	
	0040 pink	1.52	3.80	5	2.3	
	0084	0.00	0.28	4	0.14	
		0.43	0.56	2	0.5	
		0.88	1.26	4	1.1	
	0086	0.00	0.36	7	0.07	
	0087	0.00	0.07	5	0.03	
			1.14	1		
	0088	0.46	0.60	2	0.53	
		0.89	1.77	3	1.30	
		2.27	4.73	5	3.5	
	0089	0.02	0.04	3	0.03	
		1.04	1.41	4	1.23	
			3.37	1		
	0090	0.20	0.47	4	0.32	
		0.68	0.98	4	0.83	
		3.43	6.11	2		
	0091	0.07	0.22	3	0.14	
			0.77	1		
		1.76	2.92	3	2.18	
	0092	0.01	0.74	3		
		1.63	2.11	2		
	0093	0.05	0.28	4	0.16	
		0.97	2.44	5	1.42	
	0094	0.05	0.24	2		
		0.43	0.49	2	0.46	
		2.27	6.86	4	3.85	
	0095	0.11	0.15	2	0.13	
		2.08	15.7	8	6.7	
	0097	0.01	0.54	6	0.02	
	0133	0.00	0.20	4	0.08	
	0245	0.00	0.30	6	0.08	
		1.21	3.59	3	2.1	

Appendix 3. continued.

Map unit	Station (prefex 01-RME-)	Lowest Reading	Highest Reading	Number of Readings	Average	Comment
Melatroctolite and related rocks (unit 7)	0195	49.1	69.9	3	62.1	Rock
		113	185	4	132.3	alteration veins
	0199	22.9	83.7	8	60.8	
	0202	15.6	110	6	70.8	
	0217	81.1	179	10	128.6	
	0225	21.8	96.0	10	58.6	
	0251	30.1	61.8	4	42.8	Rock
		115	575	5	365	alteration veins
	0252	30.4	73.9	6	46.6	Rock
		278	342	4	304	alteration veins
	0274	36.7	69.4	6	47.4	Partly recrystallized
	0281	7.3	74.5	10	22.9	Partly recrystallized
Troctolite and related rocks (unit 8)	0142	34.1	60.5	5	46.4	Fresh
		4.97	33.8	9	17.8	Party recrystallized
	0190	7.5	18.9	9	11.9	
	0191	6.78	23.9	15	10.7	
	0191	1.4	2.71	4	2.3	Dike
	0193	4.7	9.6	10	6.8	
	0230	7.7	23.8	6	13.6	
	0256	5.2	11.7	3	7.6	
	0268	2.8	11.5	5	8.0	
Leucotroctolite and Related rocks (unit 9)	0143	9.33	19.4	6	13.5	
	0180	8.3	17.4	7	13.6	Geochronology sample
	0188	7.1	9.9	10	8.0	
	0194	1.2	6.8	6	4.6	
	0196	7.1	12.1	9	9.9	
	0200	5.0	8.6	6	6.6	
	0201	4.1	7.1	4	5.6	
	0279	5.8	8.2	10	7.2	
	0280	4.7	10.5	9	8.0	
	0308	3.4	13.6	9	6.3	
Metamorphosed gabbro (unit 11)	0066	15.9	25.0	10		
	0067	26.6	31.4	10		
	0070	5.4	12.4	5		
	0071	25.7	49.5	6	36.5	
	0072	0.82	1.03	5	0.93	Recrystallized, near margin
	0073	31.3	52.6	6	40.5	
	0074	48.4	57.9	7	53.3	
	0075	1.82	19.2	7	6.4	
		35.3	83.3	3	52.4	
	0076	45.9	65.5	7	54.5	
	0078	0.67	1.54	8	1.12	Recrystallized, near margin
	0079	1.0	3.97	5	2.0	Partly recrystallized
	0081	38.0	59.4	6	45.0	
	0082	54.5	68.2	3	59.4	
	0100	10.5	29.6	5	21.0	
	0101	0.55	0.93	5	0.78	Partly recrystallized
	0102	0.32	0.82	5	0.65	Partly recrystallized
	0103	0.46	1.20	10	0.83	Partly recrystallized
	0112	33.0	43.9	4	38.1	
	0140	0.79	2.37	10	1.2	Recrystallized, near margin
	0292	0.93	1.16	5	1.0	Recrystallized, near margin
Leucotroctolite (unit 13)	0077	0.97	9.66	4	5.7	
	0106	17.8	29.8	5	24.1	
	0107	32.0	50.2	10	36.7	
	0113	14.4	31.4	7	23.5	
	0116	21.0	44.1	7	33.3	
	0120	32.5	48.1	7	39.4	
	0121	43.0	79.8	10	54.5	Geochronology sample
	0123	51.2	69.9	10	60.8	
	0124	57.0	125	5	93.1	Near O'Connor occurrence
	0126	45.3	51.4	6	52.0	

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
LENGTH					
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
AREA					
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
VOLUME					
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
CAPACITY					
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
MASS					
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
CONCENTRATION					
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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